REPORT OF THE PROCEEDINGS

OF THE

Thirty-sixth Annual Convention

OF THE

AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION

(INCORPORATED)

HELD AT

SARATOGA, N. Y.,

June 24, 25 and 26, 1903.

CHICAGO:
THE HENRY O. SHEPARD COMPANY.
120-130 SHERMAN STREET.
1903.

OFFICERS FOR 1902-1903.

Elected at Close of Convention of 1902.

President:

GEORGE W. WEST,

Middletown, N. Y.

First Vice-President:

W. H. LEWIS,

Roanoke, Va.

Second Vice-President:

P. H. PECK,

Chicago, Ill.

Third Vice-President:

H. F. BALL,

Cleveland, Ohio.

Treasurer:

ANGUS SINCLAIR,

New York.

Secretary:

JOS. W. TAYLOR,

Chicago, Ill.

OFFICERS FOR 1903-1904.

Elected at Close of Convention of 1903.

President:

W. H. LEWIS,

Roanoke, Va.

First Vice-President:

P. H. PECK,

Chicago, Ill.

Second Vice-President:

H. F. BALL,

Cleveland, Ohio.

Third Vice-President:

J. F. DEEMS,

New York.

Treasurer:

ANGUS SINCLAIR,

New York.

Secretary:

JOS. W. TAYLOR,

Chicago, Ill.

COMMITTEES FOR CONDUCTING THE WORK OF THE ASSOCIATION FOR THE YEAR

1903-1904.

1.— Ton-mile Statistics.

To confer with the American Railway Association regarding the mileage allowance for switching engines and make positive recommendation to the convention of 1904.

C. H. QUEREAU, Chairman.
G. R. HENDERSON.
G. L. FOWLER.

2.— Coal Consumption on Locomotives.

As affected by enginemen, size of boilers and grates, loss of time on side tracks, ash pits, terminals, etc.

H. T. HERR, Chairman.
S. K. DICKERSON.
R. L. ETTINGER.

3.— Locomotive Front Ends.

To assist in tests being conducted at Purdue University, Lafayette, Indiana, by the *American Engineer and Railroad Journal,* and carry on the tests outlined in its report at the 1903 convention.

H. H. VAUGHAN, Chairman.
F. H. CLARK.
ROBT. QUAYLE.
A. W. GIBBS.
W. F. M. GOSS.

4.—Locomotive Driving and Truck Axles and Locomotive Forgings.

To follow up the proposed specifications as submitted and make final report after the meeting of the International Railway Congress in 1905.

F. H. CLARK, Chairman.
S. M. VAUCLAIN,
J. E. SAGUE,
L. R. POMEROY,
E. B. THOMPSON.
F. W. LANE.

5.—Boiler Design.

To investigate (1) the proper location of water glasses and gauge cocks in relation to the crown sheet and center line of boiler; (2) the proper slope of crown sheet expressed in inches per foot of length; (3) is the automatic low-water detector a desirable attachment for general use on locomotives?; (4) the destruction of side sheets in wide fire boxes and the reasons therefor; (5) the best form of radial stay; (6) boiler tubes, with especial reference to length, arrangement and spacing to improve circulation and reduce the trouble from leaky flues.

D. VAN ALSTYNE, Chairman,
C. E. FULLER.
O. H. REYNOLDS.
H. T. BENTLEY,
PROF. W. F. M. GOSS.

6.—Revision of Standards.

To revise the present standards on (1) shrinkage allowances, to provide for the necessary difference between cast-iron and cast-steel centers, providing for the larger diameter tires, 70 to 90 inches; (2) to revise boiler and fire-box steel specifications; (3) to revise specifications and tests for boiler tubes, providing for both steel and iron tubes; (4) to revise specifications and tests for cast-iron wheels for engine trucks and tenders.

T. A. LAWES, Chairman.
WM. FORSYTH.
WM. GARSTANG.

7.—Air Brake and Signal Instructions.

To revise the present Air Brake and Signal Instructions. To confer with committees of the Master Car Builders' Association and the Air Brake Men's Association.

A. J. COTA, Chairman.
T. R. BROWNE.
G. W. WILDIN.

8.—Piston Valves.

To conduct tests as outlined by report of the committee at convention of 1903.

WM. McINTOSH, Chairman.
J. A. PILCHER.
H. F. BALL.
G. R. HENDERSON.
C. B. YOUNG.

9.—Electrical Equipment of Shops and Shop Power-Houses.

To investigate (1) what do the manufacturers need to consider in order to more fully and satisfactorily meet the special requirements of railroads as to electrical machinery?; (2) motor driving for shops — what are the essential principles of successful systems? What are the possibilities and limitations of variable speeds in railroad shop practice?; (3) all things considered, what is the most satisfactory system for railroad shops as developed in actual practice?

C. A. SELEY, Chairman.
L. R. POMEROY.
R. V. WRIGHT.
R. ATKINSON.
E. D. BRONNER.

10.—Automatic Stokers.

Has past experience led to the belief that they may be satisfactory for general service on locomotives?

J. F. WALSH, Chairman.
H. T. HERR.
J. G. NEUFFER.

11.— Locomotive Frames.

To consider (1) the question of large locomotives with reference to a study of the causes of breakage; (2) how shall distortions, both vertical and horizontal, be provided for, and which deflection is most necessary to provide for or prevent?; (3) which is the better material, cast steel or wrought iron?

S. M. VAUCLAIN, Chairman.
J. E. SAGUE.
REUBEN WELLS.
S. HIGGINS.
ALFRED LOVELL.

12.— Cost of Locomotive Repair Shops.

The following sub-headings were suggested:

1. Power Plant — Cost per horse-power, separating boilers, engines, generators, buildings, coal and ash handling facilities, piping, switchboard, etc.
2. Locomotive Shops — Cost per cubic foot, and cost of machinery on basis of horse-power of tools and tool list.
3. Countershafting — Relative cost of direct drive as compared with countershafting.
4. Piping — Cost of air, water and steam.

R. H. SOULE, Chairman.
L. R. POMEROY.
T. H. CURTIS.
S. F. PRINCE, JR.
A. E. MANCHESTER.

13.— Safety Appliances for Locomotive Front Ends.

C. H. QUEREAU,
W. S. MORRIS.
JAS. MILLIKEN.

14.— Subjects.

H. BARTLETT, Chairman.
J. F. DEEMS.
A. W. GIBBS.

CONSTITUTION AND BY-LAWS.

ARTICLE I.

NAME.

The name of this Association shall be the "American Railway Master Mechanics' Association."

ARTICLE II.

OBJECTS OF ASSOCIATION.

The objects of this Association shall be the advancement of knowledge concerning the principles, construction, repair and service of the rolling stock of railroads, by discussions in common, the exchange of information, and investigations and reports of the experience of its members; and to provide an organization through which the members may agree upon such joint action as may be required to give the greatest efficiency to the equipment of railroads which is intrusted to their care.

ARTICLE III.

MEMBERSHIP.

SECTION 1. The following persons may become active members of the Association on being recommended by two members in good standing, signing an application for membership and agreement to conform to the requirements of the Constitution and By-Laws, or authorizing the Secretary to sign the Constitution for them;

(1) Those above the rank of general foreman, having charge of the design, construction or repair of railway rolling stock.

(2) General foremen, if their names are presented by their superior officers.

(3) Two representatives from each locomotive and car-building works.

SEC. 2. Civil and mechanical engineers, or other persons having such a knowledge of science or practical experience in matters pertaining to the construction of rolling stock as would be of special value to the Association or railroad companies, may become associate members on being recommended by three active members. The name of such candidate shall then be referred to a committee, to be appointed by the President, which shall investigate the fitness of the candidate, and report to the Executive Committee of the Association at the next annual meeting. If the report be unanimous in favor of the candidate the name shall be submitted to letter ballot, and five dissenting votes shall reject. The number of associate members shall not exceed twenty, and they shall be entitled to all the privileges of active members, excepting that of voting.

SEC. 3. All members of the Association, excepting as hereafter provided, shall be subject to the payment of such annual dues as it may be necessary

to assess for the purpose of defraying the expenses of the Association, provided that no assessment shall exceed $5 a year.

Such dues shall be payable when the amount thereof is announced by the President, at each annual meeting. Any member who shall be two years in arrears for annual dues, shall be notified of the fact, and if the arrears are not paid within three months after such notification, his name shall be taken from the roll and he be duly notified of the same by the Secretary.

SEC. 4. Any person who has been or may be duly qualified as a member of this Association will remain such until his resignation is voluntarily tendered, or he becomes disqualified by the terms of the Constitution. Members whose names have been dropped for non-payment of dues may be restored to membership by the unanimous consent of the Executive Committee on the payment of all back dues.

SEC. 5. Members of the Association, active or associate, who have been in good standing for not less than five years, and who through age or other cause cease to be actively engaged in the mechanical department of railway service, may, upon the unanimous vote of the members present at the annual meeting, be elected honorary members. The nominations must be made by the Executive Committee. The dues of the honorary members shall be remitted, and they shall have all the privileges of active members except that of voting.

SEC. 6. Any member who, during the meetings of the Association, shall be guilty of dishonorable conduct which is disgraceful to a railroad officer and a member of the Association, or shall refuse to obey the chairman when called to order, may be expelled by a two-thirds affirmative vote at any regular meeting of the Association held within one year from the date of the offense.

ARTICLE IV.

OFFICERS.

SECTION 1. The officers of the Association shall be a President, a First Vice-President, a Second Vice-President, a Third Vice-President, a Treasurer, and a Secretary; and they, with the exception of the Secretary, shall constitute the Executive Committee of the Association.

ARTICLE V.

DUTIES OF OFFICERS.

SECTION 1. It shall be the duty of the President to preside at all the meetings of the Association, appoint all committees—designating the chairman — except as hereinafter provided, and approve all bills against the Association for payment by the Treasurer.

SEC. 2. It shall be the duty of the Vice-Presidents, according to rank, to perform the duties of the President in his absence from the meetings of the Association.

SEC. 3. In case of the absence of both President and Vice-Presidents, the members present shall elect a President *pro tempore*.

SEC. 4. It shall be the duty of the Secretary to keep a full and correct

record of all transactions at the meetings of the Association; to keep a record of the names and places of residence of all members, and the name of the railway they each represent; to certify to the persons who are eligible as candidates for the Association's scholarships at the Stevens Institute of Technology; to receive and keep an account of all money paid to the Association and deliver the same to the Treasurer, taking his receipt for the amount; to receive from the Treasurer all paid bills, giving him a receipted statement of the same.

SEC. 5. It shall be the duty of the Treasurer to receive all money from the Secretary belonging to the Association; to receive all bills and pay the same, after having approval of the President; to deliver all bills paid to the Secretary at the close of each meeting, taking a receipted statement of the same and to keep an accurate book account of all transactions pertaining to his office.

ARTICLE VI.

EXECUTIVE COMMITTEE.

SECTION 1. The Executive Committee shall exercise a general supervision over the interests and affairs of the Association, recommend the amount of the annual assessment, to call, to prepare for, and to conduct general conventions, and to make all necessary purchases, expenditures and contracts required to conduct the current business of the Association, but shall have no power to make the Association liable for any debt to an amount beyond that which at the time of contracting the same shall be in the Treasurer's hands in cash, but not subject to prior liabilities. All expenditures for special purposes shall only be made by appropriations acted upon by the Association at a regular meeting.

SEC. 2. The Executive Committee shall receive, examine and approve before public reading, all communications, papers and reports on all mechanical and scientific matters; they shall decide what portion of the reports, papers and drawings shall be submitted to each convention and what portion shall be printed in the annual report.

SEC. 3. Three members shall constitute a quorum for the transaction of business.

SEC. 4. The Executive Committee shall form with a committee of the Master Car Builders' Association a Joint Committee to decide on the place of meeting for the annual convention.

ARTICLE VII.

ASSOCIATION SCHOLARSHIPS.

It shall be the duty of the Secretary to issue a circular annually intimating the date and place when and where candidates may be examined for the scholarships of the Association in the Stevens Institute of Technology, Hoboken, New Jersey.

Acceptable candidates for the scholarship shall be, first, sons of mem-

COMMITTEE ON SUBJECTS FOR INVESTIGATION AND DISCUSSION.

SEC. 2. At each annual meeting the President shall appoint a committee whose duty it shall be to report at the next annual meeting subjects for investigation and discussion, and if the subjects are approved by the Association the President, as hereinafter provided, shall appoint committees to report on them. It shall also be the duty of the committee to receive from members questions for discussion during the time set apart for that purpose. This committee shall determine whether such questions are suitable ones for discussion, and if so, they shall so report them to the Association.

COMMITTEES ON INVESTIGATION.

SEC. 3. When the Committee on Subjects has reported, and the Association approved of subjects for investigation, the President shall appoint individuals or special committees to investigate and report on them, and may authorize and appoint a *special* committee to investigate and report on any subject which a majority of the members present may approve; or individual papers may be presented to the Association after approval by the Executive Committee. Papers and reports shall be presented by abstracts, which shall not occupy more than ten minutes in the reading unless otherwise ordered by the Association.

ARTICLE X.

AMENDMENTS.

SECTION 1. The Constitution may be amended at any regular meeting by a two-thirds vote of the members present, provided that written notice of the proposed amendments has been given at a previous meeting at least six months before.

BY-LAWS.

TIME OF MEETING.

I. The regular meeting of the Association shall be held annually in June of each year.

HOURS OF SESSION.

II. The regular hours of session shall be from 9.30 o'clock A.M. to 1.30 o'clock P.M.

PLACE OF MEETING.

III. The time and place for holding the Annual Convention shall be selected by a Joint Committee composed of the President, three Vice-Presidents and Treasurer of this Association and a corresponding com-

mittee from the Master Car Builders' Association. This Joint Committee shall meet within six months after the convention and decide upon the time and place of meeting.

QUORUM.

IV. At any regular meeting of the Association, fifteen or more members entitled to vote shall constitute a quorum.

ORDER OF BUSINESS.

V. The business of the meetings of this Association shall, unless otherwise ordered by a vote, proceed in the following order:

1. Opening prayer.
2. Address by the President.
3. Acting on the minutes of the last meeting.
4. Reports of Secretary and Treasurer.
5. Assessment and announcement of annual dues.
6. Election of Auditing Committee.
7. Unfinished business.
8. New business.
9. Reports of committees.
10. Reading of papers and discussion of questions propounded by members.
11. Routine and miscellaneous business.
12. Election of officers.
13. Adjournment.

QUESTIONS FOR DISCUSSION, SPECIAL ORDER OF.

VI. Unless otherwise ordered, the discussion of questions proposed by members shall be the special order from 12 o'clock M. to 1 P.M. of each day of the annual meeting.

DECISIONS.

VII. The votes of a majority of the members shall be required to decide any question, motion or resolution which shall come before the Association, unless otherwise provided.

DISCUSSIONS.

VIII. No patentees or their agents shall be admitted in the meetings of the Association for the purpose of advocating the claims of any patent or patentee, unless by unanimous consent.

IX. No member shall speak more than twice in the discussion of any question until all the other members who want to speak, and have not been heard, have spoken, and no member shall have the floor more than five minutes at a time unless otherwise ordered.

NAMES AND ADDRESSES OF MEMBERS.

ACTIVE MEMBERS.

JOINED.	NAME.	ROAD.	ADDRESS.
1896	Adams, T. E	St. Louis & Southwestern	Pine Bluff, Ark.
1888	Addis, J. W	Texas & Pacific	Marshall, Tex.
1895	Aiken, C. L	Boston & Maine	Springfield, Mass.
1887	Aldcorn, Thos		95 Liberty st., New York City.
1902	Aldana, H. Lopez	Central Northern	Tucuman, Arg. Rep., S. A.
1903	Alexander, K. P	Ft. Smith & Western	Ft. Smith, Ark.
1892	Allen, G. S	Philadelphia & Reading	Tamaqua, Pa.
1895	Amann, W. E		520 Rialto Bldg., San Francisco, Cal.
1903	Anthony, F. S	Atlantic Coast Line	Savannah, Ga.
1892	Antz, Oscar	Lake Shore & Michigan Southern,	Elkhart, Ind.
1900	Appleyard, W. P	N. Y. N. H. & H	New Haven, Conn.
1903	Arnold, H. W	Baltimore & Ohio	Baltimore, Md.
1887	Arp, W. C	Terre Haute & Indianapolis	Terre Haute, Ind.
1903	Ashton, Harry	Intercolonial	Moncton, N. B., Can.
1901	Ashworth, Jas	Louisville & Nashville	Birmingham, Ala.
1890	Atkinson, R	Philadelphia & Reading	Reading, Pa.
1896	Atterbury, W. W	Pennsylvania	Philadelphia, Pa.
1887	Augustus, W	Keokuk & Western	Centerville, Iowa.
1886	Austin, W. L	Baldwin Loco. Works	Philadelphia, Pa.
1903	Ayers, H. B	American Loco. Co	Manchester, N. H.
1896	Babcock, C. M	Texas & Pacific	Gouldsboro, New Orleans, La.
1898	Baker, C. F	Boston Elevated	Boston, Mass.
1902	Baker, P. G	Panama	24 State st., New York. Colon. (Aspinwall).
1894	Balkam, S. T		Calle Teatro, No. 17, Monterey, N. L., Mexico.
1901	Ball, H. F	L. S. & M. S	Cleveland, Ohio.
1894	Barnes, Chas. H		86 Gainesborough st., Boston, Mass.
1888	Barnes, J. B	Wabash	Springfield, Ill.
1890	Barnum, M. K	Chicago, Rock Island & Pacific	Chicago, Ill.
1890	Barr, J. N	Chi., Mil. & St. Paul	335 Old Colony Bld., Chicago.
1895	Bartlett, Henry	Boston & Maine	Boston, Mass.
1899	Bates, F. L		1921 H st., Sacramento, Cal.
1889	Bean, S. L	A. T. & S. F	Albuquerque, N. M.
1892	Beattie, A. L	New Zealand Gov't	Wellington, N. Z.
1899	Beauclerk, T. S.	Central Argentino	Rosario de Santa Fe, Arg. Rep., S. A.
1894	Beaumont, J. G	Southern R'ys of Peru	Arequipa, Peru.
1892	Bechhold, H. G		Cleveland Frog & Crossing Co., Cleveland, Ohio.
1885	Beckert, Andrew	Louisville & Nashville	New Decatur, Ala.
1896	Belcher, A. W	Ulster & Delaware	Rondout, N. Y.
1892	Beltz, A. J	Del. Sus. & Schuylkill	Drifton, Pa.
1903	Benjamin, F. G	Chicago & North-Western	Clinton, Iowa.
1903	Bennett, W. J	Chicago, Indpls. & Louisville	Lafayette, Ind.
1900	Bentley, H. T	Chicago & North-Western	Chicago, Ill.
1902	Berry, Arthur O	Boston & Albany	Boston, Mass.
1900	Best, W. N		311 Henne Block, Los Angeles, Cal.
1892	Billingham, Jos	Baltimore & Ohio	Parkersburg, W. Va.
1903	Billingham, R. A	Pitts. Shawmut & Northern	St. Marys, Pa.

JOINED.	NAME.	ROAD.	ADDRESS.
1902	Bingaman, Chas. A	Lima Loco. & Mch. Co.	Lima, Ohio.
1901	Birse, John	Chicago Great Western	St. Paul, Minn.
1899	Bissett, J. R	Atlantic Coast Line	Savannah, Ga.
1901	Blake, R. P	Northern Pacific	St. Paul, Minn.
1900	Boardman, S. R	Gila Valley, Globe & Northern	Globe, Ariz.
1899	Boldridge, B. M	Lehigh Valley	Sayre, Pa.
1897	Bowles, C. K	Farmville & Powhatan	Chester, Va.
1895	Bradeen, J. O	N. Y. Cent. & Hudson River	E. Buffalo, N. Y.
1888	Bradley, W. F	Ann Arbor	Toledo, Ohio.
1894	Branch, Geo. E		807 Union st., Brooklyn, N. Y.
1896	Brangs, P. H		11 Broadway, New York City.
1893	Brantner, Z. T	Baltimore & Ohio	Brunswick, Md.
1900	Brassell, J. K	Cal. Northwestern	Tiburon, Cal.
1902	Brazier, F. W	N. Y. Cent. & Hudson River	New York City.
1892	Brehm, W. H	Mo. Kan. & Texas	Parsons, Kan.
1897	Briggs, D. D	Louisville & Nashville	Anniston, Ala.
1879	Briggs, R. H	K. C. M. & B	Memphis, Tenn.
1898	Bronner, E. D	Michigan Central	Detroit, Mich.
1887	Brooke, Geo. D	Iowa Central; Minn. & St. L	Minneapolis, Minn.
1892	Brown, David	Del. Lack. & Western	Scranton, Pa.
1896	Brown, M. D	Mo. Kan. & Texas	New Franklin, Mo.
1891	Brown, W. A	Central New England	Hartford, Conn.
1895	Browne, T. R		Matteawan, N. Y.
1882	Brownell, F. G		Muncie st., Muncie, Ind.
1897	Bruce, Geo. A	Great Northern	Willmar, Minn.
1890	Bruck, Henry T	Cumb. & Penna	Mt. Savage, Md.
1882	Bryan, H. S	Duluth & Iron Range	Two Harbors, Minn.
1900	Bryan, L. H	Duluth & Iron Range	Two Harbors, Minn.
1900	Buchanan, A., Jr	Delaware & Hudson	Green Island, N. Y.
1902	Buchanan, Jas	Amer. Loco. Co	Richmond, Va.
1887	Buchanan, Wm		160 W. 87th st., New York City.
1893	Bush, S. P	Buckeye Malleable Iron & Coupler Co.	Columbus, Ohio.
1903	Bushmeyer, C. J	Colorado & Southern	Denver, Colo.
1893	Butcher, Geo. W	San Antonio & A. Pass	San Antonio, Tex.
1891	Butler, L. M	N. Y. New Haven & Hartford	Auburn, R. I.
1896	Callander, R J		Caixado Carreio, 433 Para, Brazil, S. A.
1903	Calvert, W. L	Denver & Rio Grande	Helper, Utah.
1903	Campbell, A. A	Kansas City Southern	Shreveport, La.
1891	Campbell, John D		596 East 141st st., New York City
1896	Cannon, T. E	Great Northern	Barnesville, Minn.
1902	Caracristi, V. Z	Balto. & Ohio	Baltimore, Md.
1900	Carney, J. A	Chicago, Burlington & Quincy	West Burlington, Iowa.
1896	Carr, Jas	St. L. I. M. & S	Van Buren, Ark.
1903	Carson, F. C	Gulf, Colo. & Santa Fe	Cleburne, Tex.
1889	Casanave, F. D		1710 Market st., Philadelphia, Pa.
1890	Casey, J. J	Haskell & Barker	Michigan City, Ind.
1892	Chamberlin, E	Brooklvn Rapid Transit	Brooklyn, N. Y.
1903	Chambers, C. E	Central R. R. of N. J	Jersey City, N. J.
1893	Chambers, Jno. S	Atlantic Coast Line	Wilmington, N C.
1901	Chase, C. F	Amer. Loco. Co	Manchester, N. H
1896	Chase, F. A	Hannibal & St. Joseph	St. Joseph, Mo.
1893	Childs, H. A		
1898	Christopher, J	Toronto, Hamilton & Buffalo	Hamilton, Ontario, Can.
1899	Christie, W. K	Pere Marquette	Saginaw, Mich.
1902	Churchward, G. J	Great Western	Swindon, England.
1899	Clark, F. H	Chicago, Burlington & Quincy	Chicago, Ill.

JOINED.	NAME.	ROAD.	ADDRESS.
1886	Clark, Isaac W		Fayetteville, N. C.
1903	Clark, J. H	Staten Island R. T	Clifton, S. I, New York.
1897	Clarke, Owen		Marshall, Texas.
1903	Clarkson, W. S	Northern Pacific	Livingston, Mont.
1901	Clay, S. B		Spadra, Ark.
1893	Cleaver, F. C	Rutland	Rutland, Vt.
1892	Clifford, C. J		372 First ave. Elizabeth, N. J.
1887	Clifford, J. G		Tenth and Kentucky sts., Louisville, Ky.
1887	Cloud, John W		82 York Road, King's Cross, London, Eng.
1903	Cockfield, William	Interoceanic	Puebla, Mexico.
1896	Cole, F. J	Amer. Loco. Co	Schenectady, N. Y.
1891	Collinson, Jas		1018 Topeka ave., Topeka, Kan.
1901	Conlon, T. M	Southern	Charleston, S. C.
1890	Conolly, J. J	Dul. So. Shore & Atlantic	Marquette, Mich.
1879	Cook, John S	Georgia	Augusta, Ga.
1898	Cooper, C. J	Toledo & Ohio Central	Kenton, Ohio.
1901	Cooper, Chas. T	Toledo & Ohio Central	Kenton, Ohio.
1898	Cooper, D. S	Rich. Fred. & Potomac	Richmond, Va.
1876	Cory, C. H	Cin., Hamilton & Dayton	Lima, Ohio.
1902	Cota, A. J	Chicago, Burlington & Quincy	Chicago.
1900	Courtney, D. C		1130 Sheffield st., Allegheny, Pa.
1900	Crawford, D. F	Pennsylvania Lines	Pittsburgh, Pa.
1885	Cromwell, A. J		1411 Hollins st., Baltimore, Md.
1902	Cross, C. W	Lake Shore & Mich. So	Elkhart, Ind.
1902	Cross, J. W	Great Western Ry	Swindon, England.
1893	Cross, W	Canadian Pacific	Montreal, Can.
1896	Cullinan, J	Col. Sand. & Hocking	Columbus, Ohio.
1899	Cumback, R. O		Box 789, Beaumont, Tex.
1899	Cunningham, Jas		
1900	Curley, M. S	Gulf & Ship Island	Gulfport, Miss.
1903	Curry, H. M	Northern Pacific	Staples, Minn.
1903	Curtis, J. H.	Louisville & Nashville	Louisville, Ky.
1872	Cushing, G. W		Evanston, Ill.
1890	Davies, J. M		56 Broad st., Plattsburgh, N. Y.
1899	Davis, Chas. H		25 Broad st., New York City.
1892	Davis, Ed E	N. Y. Cent. & Hudson River	West Albany, N. Y.
1899	Davis, M. R	Portland & Rumford Falls	Rumford Falls, Me.
1900	Davisson, F. E	San Pedro, Los Angeles & Salt Lake	Los Angeles, Cal.
1897	Dawson, E.	Union Pac	Omaha, Neb.
1903	Dawson, L. L	Illinois Central	McComb, Miss.
1896	Deeble, Wm. R	Tasmania Govt	Launceston, Tasmania.
1891	Deems, J. F	N. Y. Central & Hudson River	New York City.
1896	De Gress, C	Mex. Nat. Construc. Co	Colima, Mex.
1897	Delaney, C. A	Amer. Loco. Co	Scranton, Pa.
1895	Delaney, H		14 Stuyvesant Place, Staten Island, N. Y.
1899	Delano, F. A	C. B. & Q	Chicago, Ill.
1900	Demarest, T. W	Pennsylvania Lines	Ft. Wayne, Ind.
1903	Deverill, A. C	Great Northern	St. Paul, Minn.
1896	Dickerson, S. K	Lake Shore & Michigan South'n	Collinwood, Ohio.
1887	Dickson, G. L	Amer. Loco. Co	Scranton, Pa.
1902	Dickson, Geo	Mo. Pacific	Baring Cross, Ark.
1900	Dillon, S. J	Pennsylvania	South Amboy, N. J.
1894	Dixon, W. F		Podolsk, Moscow, Govt., Russia.
1897	Doebler, C. H	Wabash	Springfield, Ill.
1898	Dolan, S. M	Southern	Selma, Ala.
1896	Donohue, Geo	Erie	Meadville, Pa.

JOINED.	NAME.	ROAD.	ADDRESS.
1903	Doonan, W. F.	Great Northern	**Kalispell, Mont.**
1893	Dow, Jas. M		**Kenton, Ohio.**
1899	Downing, T. M	Frisco System	**Cape Girardeau, Mo.**
1893	Drury, Michael J	Atchison, Topeka & Santa Fe	**Winslow, Ariz.**
1903	Dunlap, P. T	Gulf, Colorado & Santa Fe	**Temple, Tex.**
1900	Dunn, A. J	Virginia & Southwestern	**Bristol, Va.**
1896	Dunn, J. F	Oregon Short Line	**Salt Lake City, Utah.**
1902	Dunn, M	Pennsylvania Lines	**Columbus, Ohio.**
1900	Edwards, J. A	Rio Grande Southern	**Ridgway, Colo.**
1899	Egan, J. A	Mexican Southern	**Oaxaca, Mex.**
1900	Elden, Edw	N. Y. C. & H. R	**W. Albany, N. Y.**
1869	Elliott, Henry		**East St. Louis, Ill.**
1899	Ellis, H. D	Anglo-Chilian Nitrate & R'y Co.	**Tocapilla, Chili.**
1895	Ellis, John	Maine Central	**Waterville, Me.**
1893	Ellis, John J	C. St. P. M. & O	**St. Paul, Minn.**
1901	Emerson, G. H	Great Northern	**St. Paul, Minn.**
1893	English, H. W		**Birmingham, Ala.**
1893	English, Richard		**1917 Mission st., San Francisco, Cal.**
1881	Ennis, W. C	Delaware & Hudson Co	**Carbondale, Pa.**
1898	Erskine, A. S		**Houghton, Mich.**
1892	Esson, R. C		**765 Julian ave., San Diego, Cal.**
1898	Ettinger, R. L	C. C. C. & St. L	**Indianapolis, Ind.**
1900	Ewing, J. J	Chesapeake & Ohio	**Richmond, Va.**
1900	Feeley, T. M	Southern	**Birmingham, Ala.**
1885	Ferguson, G. A	N. Y. C. & H. R	**Depew, N. Y.**
1901	Fildes, Thos	Long Island	**Richmond Hill, L. I., N. Y.**
1892	Fitzmorris, Jas	Chicago Junction	**Union Stock Yards, Chicago, Ill.**
1903	Fleischer, J. F	Chicago & North-Western	**Kaukauna, Wis.**
1903	Flory, B. P	Lehigh Valley	**So. Bethlehem, Pa.**
1901	Fogg, J. W	Chicago Ter. Transfer	**E. Chicago, Ind.**
1895	Foller, P. P	Pennsylvania	Oil City, Pa.
1896	Foque, T. A	M. St. Paul & S. Ste. M	**Minneapolis, Minn.**
1901	Forbes, S. F	Chicago, Rock Island & Pacific	Chicago, Ill.
1900	Forsyth, A	Chicago, Burlington & Quincy	Aurora, Ill.
1888	Forsyth, Wm	M. E. *The Railway Age*	Chicago, Ill.
1890	Foulk, John	Jacksonville & St. Louis	Litchfield, Ill.
1877	Fowle, I. W		Riverside, **California.**
1891	French, R. E	Southern Pacific	Kern, Kern Co., **Cal.**
1898	Frey, N	Chicago, Bur. & Quincy	La Crosse, Wis.
1902	Fritchey, F. W		303 New England Bldg., Kansas City, Mo.
1903	Fryburg, F. M	Great Northern	Havre, Mont.
1890	Fuller, C. E	Chicago & Alton	Bloomington, Ill.
1872	Fuller, Wm		213 Kennard st., Cleveland, Ohio.
1893	Gage, George W		Box 345 Epping, N. H.
1897	Gaines, F. F	Lehigh Valley	Wilkesbarre, Pa.
1891	Galbraith, R. M		Pine Bluff, Ark.
1901	Gallagher, G. A	Great Northern	W. Superior, Wis.
1897	Gardner, A	C. & C. V	Cooperstown, N. Y.
1887	Garstang, Wm	C. C. C. & St. L	Indianapolis, Ind.
1900	Gaskins, W. B	Pecos Valley & Northeastern	Roswell, N. M.
1886	Gentry, T. W	American Loco. Co	Richmond, Va.
1899	Gibb, T. M	Crystal River	Redstone, Colo.
1888	Gibbs, A. W	Pennsylvania	Altoona, Pa.
1890	Gibbs, George	Rapid Transit Subway Const. Co.	18-21 Park Row Bldg., N. Y.

JOINED.	NAME.	ROAD.	ADDRESS.
1902	Gibson, J. A.	Cleveland, Cin., Chic. & St. Louis	Urbana, Ill.
1896	Gill, Jno	C. I. & L.	Lafayette, Ind.
1891	Gillis, H. A.	American Loco. Co	Richmond, Va.
1883	Gilmore, W. L	N. Y. C. & St. L.	Cleveland, Ohio.
1893	Gilmour, George		N. Y. Telephone Co., 15 Dey st., New York.
1903	Gilmour, R. H.	American Loco. Co	Dunkirk, N. Y.
1890	Givin, F. A.		Box 595 Wilmerding, Pa.
1891	Glass, John C	Pennsylvania	Verona, Pa.
1880	Gordon, H. D		71 John st., New York.
1903	Gossett, H. O	Velasco, Brazos & Northern	Velasco, Texas.
1900	Gould, J. E	Cin., Hamilton & Dayton	Lima, Ohio.
1899	Gould, R.	Buenos Ayres Great Southern,	Buenos Ayres, Arg. Rep., S. A.
1892	Graham, Charles	Philadelphia & Reading	Philadelphia, Pa.
1894	Graham, J. A.		27 Park ave., Detroit, Mich.
1903	Graham, S. C	Chicago & North-Western	Lake City, Iowa.
1903	Grandy, W. S	Atch., Topeka & Santa Fe	Newton, Kan.
1894	Grant, A. S	St. Louis, Iron Mount'n & South'n	Argenta, Ark.
1889	Greatsinger, J. L.	Brooklyn Rapid Transit	Brooklyn, N. Y.
1897	Greaven, Luis	Interoceanic	Puebla, Mex.
1895	Green, Wilbur	San Antonio & Aransas Pass	Yoakum, Tex.
1885	Griffith, Fred B		1049 Elmwood ave., Buffalo, N. Y.
1893	Gross, R. J.	American Loco. Co	25 Broad st., New York.
1896	Groves, J. R	Colorado Midland	Colorado City, Colo.
1900	Gurry, Geo		International Power Co., Providence, R. I.
1893	Hainen, J.	Southern	Greensboro, N. C.
1898	Hair, John	Balto. & Ohio S.-W.	Washington, Ind.
1902	Hammett, P. M	Maine Central	Portland, Me.
1891	Hancock, Geo. A	St. Louis & San Francisco	Springfield, Mo.
1893	Hancock, Wm. S.		3148 Olive st., St. Louis, Mo.
1896	Hanglin, J. A.	Hot Springs	Malvern, Ark.
1899	Hansgen, J. A.	Wabash	Springfield, Ill.
1893	Hardie, Jas		Hardie & Co., Valparaiso, Chili.
1903	Harned, A. W	Chicago Short Line	Cleveland, Ohio.
1900	Harrington, W	Boston & Maine	Worcester, Mass.
1902	Harris, J. D.	Baltimore & Ohio	Baltimore, Md.
1896	Harrison, Jno	San Paulo	San Paulo, Brazil, S. A.
1898	Harrison, F. J	Buffalo, Rochester & Pittsburg	Du Bois, Pa.
1903	Hartigan, B	Rutland	Rutland, Vt.
1901	Haselton, G. H.	N. Y. C. & H. R	W. Albany, N. Y.
1869	Haskell, B.		85 Pleasant st., Wakefield, Mass.
1888	Hassman, Wm	Shelton Bros. & Hassman	Paducah, Ky.
1875	Hatswell, T. J	Pere Marquette	Saginaw, E. S., Mich.
1900	Hawkins, B. H	Gold Car Heating & Light. Co.	New York City.
1903	Hawkins, R. D.	Great Northern	St. Paul, Minn.
1895	Hawksworth, D	Burlington & Missouri River	Plattsmouth, Neb.
1899	Hawthorne, J.	Lehigh Valley	Sayre, Pa.
1898	Hayden, J. C	Nor. R'y of Costa Rica	Limon, Costa Rica.
1903	Hayes, W. C	Erie	Meadville, Pa.
1896	Hayward, H. S.	Pennsylvania	Jersey City, N. J.
1891	Hedley, F.	Manhattan Elevated	New York City.
1896	Heers, L. B	Pitts., Shaw. & Nor	St. Mary's, Pa.
1887	Heintzleman, T. W.	Southern Pacific	Sacramento, Cal.
1892	Henderson, G. R.		113 Cass st., Chicago, Ill.
1897	Hepburn, G. W.	Ches. & Ohio	Covington, Ky.
1892	Herr, Edwin M		Edgewood Park, Pa.
1903	Herr, H. T	Norfolk & Western	Roanoke, Va.

JOINED.	NAME.	ROAD.	ADDRESS.
1895	Hibbard, H. Wade	Cornell University	Ithaca, N. Y.
1903	Hickey, F. P	Seaboard Air Line	Raleigh, N. C.
1901	Hickey, P. J	C. C. C. & St. L	Mattoon, Ill.
1890	Higgins, S	Southern	Washington, D. C.
1901	Hildreth, F. F	Terre Haute & Indianapolis	Terre Haute, Ind.
1901	Hilferty, C. D		316 Summit ave., Schenectady, N. Y.
1887	Hill, Jas. W	P. & Pekin Union	Peoria, Ill.
1902	Hillman, C. R	San Paulo	San Paulo, Brazil, S. A.
1902	Hobson, W. P	Ches. & Ohio	Hinton, W. Va.
1900	Hodgkins, W. W	Boston & Maine	Mechanicsville, N. Y.
1899	Hoffman, R. F		Box 774, Schenectady, N. Y.
1901	Hogan, C. H	N. Y. C. & H. R	East Buffalo, N. Y.
1892	Holland, W. D	Guayaquil & Quito	Duran, Ecuador, S. A.
1901	Holtz, D	Western Maryland	Union Bridge, Md.
1890	Homer, John C	Detroit & Southern	Springfield, Ohio.
1900	Hone, A. C	Louisville & Nashville	Louisville, Ky.
1896	Hopwood, Jno	Argentine Gt. West., Mendoza, Argentine Rep., S. A.	
1896	Horrigan, Jno	E. J. & E	Joliet, Ill.
1892	Howard, C. H		504 Columbia Bldg., St. Louis, Mo.
1896	Howard, Jno	N. Y. C. & H. R	Depew, N. Y.
1903	Hufman, W. H	Chicago & North-Western	Baraboo, Wis.
1899	Hudson, H. G		135 Broadway, Alliance, Ohio.
1890	Hufsmith, F	I. & G. N	Palestine, Tex.
1890	Humphrey, A. L	Westinghouse Air Brake Co	Chicago, Ill.
1901	Hutchinson, C. B	Boston & Maine	Lyndonville, Vt.
1896	Hyndman, F. T	Buffalo, Rochester & Pittsburg	Du Bois, Pa.
1900	Impett, J. J	Cent. R'y of Peru	Lima, Peru, S. A.
1896	Inge, T. S	Danville & Western	Danville, Va.
1900	Irwin, J. E	Marietta, Columbus & Clevel'd	Marietta, Ohio.
1888	Jackson, O. H	Indianapolis Union	Indianapolis, Ind.
1899	James, E. T	Lehigh Valley	E. Buffalo, N. Y.
1896	James, Geo	N. Y. C. & St. L	Sta. S, Chicago, Ill.
1902	Jenkins, Wm	So. Car. & Ga. Ext	Blacksburg, S. C.
1900	Jennings, Thos	Boston & Maine	Keene, N. H.
1890	Jennings, Wm		Ciudad Porfirio Diaz, Mex.
1896	Johnson, A. B	Baldwin Loco. Works	Philadelphia, Pa.
1902	Johnson, Ben	Mexican Central	City of Mexico.
1878	Johnson, J. B	Arkansas Midland	Helena, Ark.
1887	Johnson, L. R	Canadian Pacific	Montreal, Canada.
1903	Johnson, R. A	Sonora	Guaymas, Sonora, Mex.
1898	Johnson, R. H	Wiggins Ferry Co	St. Louis, Mo.
1903	Johnson, W. O	Iowa Central	Marshalltown, Iowa.
1888	Joughins, G. R	Santa Fe Pacific	San Bernardino, Cal.
1903	Jungling, M	Tifton, Thomasville & Gulf	Kingwood, Ga.
1896	Justice, D. J		Eighth and Chestnut sts., Louisville, Ky.
1890	Kalbaugh, I. N	W. Virginia Cent. & Pittsburg	Elkins, W. Va.
1903	Kapp, W. F.	Rich., Fred. & Potomac	Richmond, Va.
1892	Keegan, Jas. E	Grand Rapids & Indiana	Grand Rapids, Mich.
1896	Kells, Willard	Lehigh Valley	Sayre, Pa.
1896	Kelly, Wm	Great Northern	Everett, Wash.
1894	Kennedy, Jas	Jamaica	Kingston, Jamaica.
1893	Kenney, Geo. W	Rutland	Rutland, Vt.
1901	Keyworth, T. E	Cuban Central R'ys, Ltd	Sagua La Grande, Cuba.

JOINED.	NAME.	ROAD.	ADDRESS.
1890	Killen, W. E	C. P. & St. L. / Alton Terminal	Jacksonville, Ill.
1903	Kilpatrick, J. B	Chicago, Rock Island & Pacific	Chicago, Ill.
1900	Kilpatrick, R. F	Dela., Lack. & Western	Kingsland, N. J.
1903	Kinnaird, L. S	Clev., Akron & Columbus	Mt. Vernon, Ohio
1902	Kipp, A. R	Wisconsin Central	Fond du Lac, Wis.
1899	Knapp, L. I	5 West 34th st	New York City.
1903	Knight, H. P	Baltimore & Ohio	New Castle Junc., Pa.
1902	Knight, Wm. Edw	United Railways of Havana	Havana, Cuba.
1902	Krauss, J. I	Outchita & North West	Clarks, La.
1899	Kummer, W. M		409 Litchfield st., West Bay City, Mich.
1899	Lachlan, Wm	E de F. Porto Alegre & New Hamburg,	Porto Alegre, Rio Grande de Sul, Brazil.
1902	Lahey, John	Kansas City Southern	Shreveport, La.
1900	Laird, Alex	Little Kanawha	Parkersburg, W. Va.
1898	Lake, E. M		Crowley, La.
1894	Lang, V. B	Alabama Great Southern	Birmingham, Ala.
1888	Lape, C. F	Scully Steel & Iron Co	Chicago, Ill.
1891	Lawes, T. A	C. & E. I	Danville, Ill.
1896	Lawrence, J. L	Cumb. Valley	Chambersburg, Pa.
1901	Layman, W. W		Parkersburg, W. Va.
1890	Leach, H. L		Room 45, Mason Bldg., Boston, Mass.
1903	Leach, W. B	Boston & Albany	Springfield, Mass.
1892	Lee, C. W	Southern	Lawrenceville, Va.
1888	Leigh, F. J		30 Kenilworth Road, Ealing, London W., Eng.
1890	Leonard, A. G	Union Stock Yards	Chicago, Ill.
1876	Lewis, W. H	Norfolk & Western	Roanoke, Va.
1896	Lindoff, Geo	A. T. & S. F	Argentine, Kan.
1896	Linstrom, Chas	Illinois Central	Vicksburg, Miss.
1903	Litton, Frances H	Shansi Honan Ry	Shanghai, China.
1890	Lloyd, T. S	Dela., Lack. & West	Scranton, Pa.
1895	Lonergan, P. T.	Rutland	Rutland, Vt.
1899	Lovell, Alfred	A. T. & S. F	Topeka, Kan.
1900	Lowell, W. W	Han. & St. Joseph	Brookfield, Mo.
1897	Lucas, W. O	Central Argentine	Rosario, Arg. Rep., S. A.
1903	Lyddon, H. A	Northern Pacific	Gladstone, Minn.
1894	Lyon, Tracy	Chicago, Great Western	St. Paul, Minn.
1903	MacBain, D. R	Michigan Central	Jackson, Mich.
1887	Macbeth, Jas	N. Y. Central	East Buffalo, N. Y.
1890	Macfarlane, T. W		Cape Girardeau, Mo.
1899	Machesney, A. G	Baldwin Loco. Works	Philadelphia, Pa.
1876	Mackenzie, John		60 Hawthorne ave., Cleveland, Ohio.
1892	Mackinnon, Geo. S	Canadian Pacific	Winnipeg, Man., Canada
1896	Maher, P	Indiana, Illinois & Iowa	Kankakee, Ill.
1896	Mahl, F. W	Southern Pacific	Sacramento, Cal.
1899	Malone, T. M	Ulua Commercial Co	Puerto Cortez, Honduras.
1895	Mallinson, E. P		49 Ashford st., Brooklyn, N. Y.
1894	Manchester, A. E	C. M. & St. P	West Milwaukee, Wis.
1902	Manchester, H. C	Boston & Maine	Mechanicsville, N. Y.
1893	Manning, J. H	Can. Pacific	Winnipeg, Man.
1898	Marchbanks, James	Wellington & Manawatu	Wellington, N. Z.
1896	Marden, J. W	Boston & Maine	Boston, Mass.
1903	Markle, T. M	Pacific Coast	San Luis Obispo, Cal.
1897	Marshall, B. F		Mt. Vernon, Ohio.
1890	Marshall, E. S		St. Louis, Mo.

JOINED.	NAME.	ROAD.	ADDRESS.
1891	Marshall, W. H	Lake Shore & Michigan South'n	Cleveland, Ohio.
1903	May, H. C	Clev., Cin., Chgo. & St. Louis	Louisville, Ky.
1891	McConnell, J. H	American Loco. Co	Pittsburg, Pa
1896	McCormick, A	Chicago, Rock Island & Pac	Fairbury, Neb.
1892	McCuen, J. P	C. N. O. & T. P	Ludlow, Ky.
1903	McCuen, R. E	Lexington & Eastern	Lexington, Ky.
1891	McDonough, James	Tex. & N. O.; Gal., H. & Nor	Houston, Tex.
1893	McElvaney, C. T	Mo., Kansas & Texas	Denison, Tex.
1903	McGrath, J. T	Grand Trunk	Ft. Gratiot, Mich.
1903	McHattie, T	Grand Trunk	Montreal, Can.
1890	McIntosh, Wm	Central R. R. of N. J	Jersey City, N. J
1893	McKee, G. S	Mobile & Ohio	Mobile, Ala.
1901	McKeen, W. R., Jr	Union Pacific	Omaha, Neb.
1896	McLean, W. J	Bell. Bay & Brit. Col	New Whatcom, Wash.
1901	McLeish, W. J	Evansville & Terre Haute	Evansville, Ind.
1894	McMasters, Chas. J	Rutland	Malone, N. Y.
1896	McNabb, T	Great Falls & Canada	Great Falls, Mont.
1890	McNaughton, Jas	Amer. Loco. Co	Dunkirk, N. Y.
1901	Meaney, H. M	Gulf & Ship Island	Gulfport, Miss.
1888	Medway, John		33 Lexington ave., Cambridge, Mass.
1895	Mellin, C. J	Amer. Loco. Co	Richmond, Va.
1900	Mendenhall, C. M		Pressed Steel Car Co., Allegheny, Pa.
1903	Menzel, W. G	Wisconsin Central	Fond du Lac, Wis.
1892	Mertsheimer, F	Denver & Rio Grande	Denver, Colo.
1887	Michael, J. B	Southern	Knoxville, Tenn.
1885	Millen, Thos	Metropolitan Street Ry	106 W. 51st st., New York.
1889	Miller, E. A	N. Y. C. & St. L	Conneaut, Ohio.
1890	Miller, Geo. A	Florida East Coast	St. Augustine, Fla.
1896	Miller, G. W	Erie	Elmira, N. Y.
1903	Miller, J. B	St. Louis Southwestern of Tex	Waco, Tex.
1901	Miller, S. W	Pennsylvania Lines	Columbus, Ohio.
1903	Miller, W. J	St. Louis Southwestern of Tex	Tyler, Tex.
1893	Minshull, P. H	N. Y. O. & W	Middletown, N. Y.
1892	Minto, H. M	Louisville & Nashville	Mobile, Ala.
1888	Minton, A. B	Mobile & Ohio	Jackson, Tenn.
1892	Mitchell, A. E	Northern Pacific	St. Paul. Minn.
1903	Moir, William	Northern Pacific	So. Tacoma, Wash.
1898	Moler, A. L	Vicksburg, Shreveport & Pac	Monroe, La.
1901	Monahan, J. J	Louisville & Nashville	Paris, Tenn.
1890	Monkhouse, H	Rome Loco. & Mach. Wks	Rome, N. Y.
1903	Monlaverde, F	Paulista	Jundiahy, Brazil.
1903	Monroe, M. S	Chicago, Rock Island & Pacific	Trenton, Mo.
1884	Montgomery, Wm	Cent. of N. J	Lakehurst, N. J.
1901	Morgan, J. B	Toledo & Ohio Central	Bucyrus, Ohio.
1900	Morton, G. C	Natl. Tehuantepec	Coatzacoalcos, V. C., Mex.
1890	Moore, J. H		No. 1 Menlo Place, Rochester, N. Y.
1895	Moraga, Anselmo	Chilian State	Santiago, Chili.
1896	Moran, Robt	Louisville & Nashville	Nashville, Tenn.
1887	Morris, W. S	Erie	Meadville, Pa.
1902	Morrison, F. B	Panama	24 State st., New York City.
1901	Morse, C. S	Wheeling & Lake Erie	Ironville, Ohio.
1890	Morse, F. W	Grand Trunk	Montreal, Canada.
1901	Muchnic, C. M	Denver & Rio Grande	Denver, Colo.
1903	Mudd, H. K	Chicago, Cin. & Louisville	Richmond, Ind.
1899	Muhlfeld, J. E	Balto. & Ohio	Baltimore, Md.
1890	Murphy, P. H		Murphy Car Roof Co., East St. Louis, Ill.
1903	Murrian, W. S	Southern	Alexandria, Va.

JOINED.	NAME.	ROAD.	ADDRESS.
1894	Nettleton, W. A		3531 Walnut st., Kansas City, Mo.
1898	Neubert, G. T	Kansas City Belt	Kansas City, Mo.
1892	Neuffer, John G	B. & O. S.-W	Cincinnati, Ohio.
1901	Neville, John		San Luis Potosi, Mexico.
1896	Neward, F. H	Pontiac, Ox. & Northern	Pontiac, Mich.
1903	Nichols, H. E	Minn. Transfer	St. Paul, Minn.
1875	Noble, L. C		Fisher Bldg., Chicago.
1902	Nolan, J. C	Southern Arkansas	Ruston, La.
1899	Nolan, J. P	Morgan's L. & T. R.R. & S.S. Co	Algiers, La.
1896	Norsworthy, N. W	Norfolk & Western	Crewe, Va.
1902	Nutt, Geo. B	Queensland Govt. Rys	Brisbane, Queensland.
1896	Nuttall, W. H	Manistee & N. East'n	Manistee, Mich.
1890	O'Brien, John	Rich. & Petersburg	Manchester, Va.
1903	O'Hearne, J. E	Wheeling & Lake Erie	Norwalk, Ohio.
1890	O'Herin, Wm	Mo., Kan. & Tex	Parsons, Kan.
1895	O'Leary, D	Pacific Coast Co	Seattle, Wash.
1901	Ord, C. R	Canadian Pacific	McAdam Junction, N. B., Can.
1895	Orland, W. P	C. C. C. & St. L	Wabash, Ind.
1897	Owens, W. H	Southern	Manchester, Va.
1901	Parish, LeGrand	L. S. & M. S	Englewood, Ill.
1900	Parker, M. B	Rockwood & Tenn. River	Rockwood, Tenn.
1901	Park, S. T		4213 Ellis ave., Chicago.
1903	Park, P. D	Reid Newfoundland Co's	Whitbourne, N. F.
1903	Passmore, H. E	Toledo & Ohio Central	Kenton, Ohio.
1879	Patterson, J. S		Galena Oil Co., Cincinnati, Ohio.
1903	Paul, W. M	Gal., Houston & Henderson	Galveston, Tex.
1891	Paxton, Thos	Frisco System	Ft. Smith, Ark.
1903	Pearsall, D. M	Atlantic Coast Line	Florence, S. C.
1899	Pearse, H	Buenos Ayres & Rosario	Campana, Arg. Rep., S. A.
1887	Peck, Peter H	C. & W. I. and Belt	Chicago, Ill.
1901	Pengelly, J. H	Mexican National	Salazar, Mex.
1899	Pennington, J. H	Dela., Susq. & Schuyl	Drifton, Pa.
1897	Peyton, H. T	Atchison, Topeka & Santa Fe	Wellington, Kan.
1897	Pflager, H. M	Amer. Steel Foundries	St. Louis, Mo.
1900	Phillips, C	New Orleans & Northeastern	Meridian, Miss.
1903	Piccioli, J	Colorado & Wyoming	Pueblo, Colo.
1902	Pilcher, J. A	Norfolk & Western	Roanoke, Va.
1885	Pitkin, A. J	American Loco. Co	25 Broad st., New York.
1901	Place, F. E	Illinois Central	Burnside Shops, Chicago.
1900	Plank, P. D	Louis., Hend. & St. L	Cloverport, Ky.
1903	Platt, J. G	Erie	Meadville, Pa.
1881	Player, John		Franklin, Pa.
1897	Pollitt, Harry	Great Central	Fernlea, Altricham, Cheshire, Eng.
1900	Post, W. F		Watkins Fdy. & Mch. Co., Hattiesburg, Miss.
1897	Potton, J	Texas & Pacific	Big Springs, Tex.
1903	Pratt, E. W	Chicago & North-Western	Missouri Valley, Iowa.
1903	Prendergast, W. H	Central of Georgia	Columbus, Ga.
1891	Prescott, C. H	Spokane Falls & Nor	Spokane, Wash.
1900	Prince, S. F., Jr	Philadelphia & Reading	Reading, Pa.
1902	Punshon, Eli	Kansas City So	Pittsburg, Kan.
1890	Purves, T. B., Jr	Boston & Albany	Boston, Mass.
1888	Quayle, Robert	Chicago & North-Western	Chicago, Ill.
1895	Quereau, C. H	N. Y. C. & H. R	W. Albany, N. Y.

JOINED.	NAME.	ROAD.	ADDRESS.
1890	Randolph, L. S	Virginia Polytechnic Institute	Blacksburg, Va.
1903	Records, J. W	Santa Fe Central	Torrance, N. M.
1901	Redding, D. J	Pitts. & Lake Erie	McKee's Rocks, Pa.
1902	Reid, W. L	American Loco. Co	Dunkirk, N. Y.
1883	Renshaw, W	Illinois Central	Chicago, Ill.
1892	Rettew, C. E	D. & H. Co	Carbondale, Pa.
1896	Reynolds, O. H	American Loco. Co	New York City.
1887	Rhodes, G. W	Burlington & Missouri River	Lincoln, Neb.
1899	Rhodes, L. B	Georgia Southern & Florida	Macon, Ga.
1901	Richmond, W. H	Lake Superior & Ishpeming	Marquette, Mich.
1903	Rickard, W. W	Cananea Con. Copper Co. R'y	La Cananea, Sonora, Mex.
1897	Rickert, Mason		Delaware, Ohio.
1894	Riley, George N	McKeesport Connecting	Pittsburg, Pa.
1899	Risteen, F. N	Atchison, Topeka & Santa Fe	Topeka, Kan.
1902	Robb, J. M	Canadian Northern	Winnipeg, Man.
1901	Robb, W. D	Grand Trunk	Montreal, P. Q.
1882	Roberts, E. M		Springfield, Ohio.
1901	Roberts, Jos	Union Pacific	Armstrong, Kan.
1896	Roberts, J. W		1124 Cornell ave., Indianapolis, Ind.
1891	Roberts, Mord	Kansas City Southern	Pittsburg, Kan.
1895	Robinson, Frank	Maine Central	Bangor, Me.
1898	Robinson, J. T	Southern	Spencer, N. C.
1896	Rogers, M. J		1008 West 24th st., Kansas City, Mo.
1903	Rogers, R. H	Balto. & Ohio	Cumberland, Md.
1901	Rommel, C. T	B. & O. Ins. Amer. Loco. Co	Richmond, Va.
1900	Roope, Thos	C. R. I. & P	Topeka, Kan.
1896	Rosing, W. H. V	Illinois Central	Chicago, Ill.
1891	Rotheran, T. F	Western Australian Govt. R'ys	Tremantle, Australia.
1895	Royal, C. B		180 Old Colony Bldg., Chicago, Ill.
1898	Rumney, T	Erie	Meadville, Pa.
1896	Rusch, Peter C	Buffalo, Rochester & Pittsburg	Bradford, Pa.
1903	Russell, W. H	Southern Pacific	Oakland, Cal.
1893	Ryan, E	Galv., Houston & San Antonio	San Antonio, Tex.
1892	Ryan, Patrick	Louisville & Nashville	Russellville, Ky.
1891	Ryan, J. J	Southern Pacific	Houston, Tex.
1892	Sague, J. E	Amer. Loco. Co	25 Broad st., New York.
1887	Sample, N. W	Baldwin Loco. Works	Philadelphia, Pa.
1891	Sanborn, J. N		Alexandria, Va.
1896	Sanderson, R. P. C	Seaboard Air Line	Portsmouth, Va.
1896	Sauter, A	Norfolk & Western	Portsmouth, Ohio.
1903	Schilling, R. P	Dela., Lack. & Western	Utica, N. Y.
1874	Schlacks, Henry		Denver, Colo.
1901	Seabrook, C. H	St. Louis Southwestern	Pine Bluff, Ark.
1875	Sedgwick, E. V		Galena Oil Co., Franklin, Pa.
1900	Seidell, G. W	Southern	Birmingham, Ala.
1900	Seley, C. A	Chi. R. I. & Pacific	Chicago, Ill.
1899	Shepard, L. A		100 Broadway, New York City.
1903	Shepard, Samuel	Minn., St. P. & S. Ste. Marie	Enderlin, N. D.
1890	Shields, J. C	Mineral Range	Hancock, Mich.
1883	Sinclair, Angus		174 Broadway, New York City.
1900	Singer, Frank	Midland Terminal	Canon City, Colo.
1892	Sinnott, W	Baltimore & Ohio	58th st., Philadelphia, Pa.
1896	Skinner, Calvin	Chicago & Alton	Bloomington, Ill.
1889	Skinner, H. M. C		88 Walnut st., Fall River, Mass.
1900	Slack, J. R	Delaware & Hudson	Albany, N. Y.
1893	Slater, Frank	Chicago & N.-W	Escanaba, Mich.

JOINED.	NAME.	ROAD.	ADDRESS.
1889	Slater, John C		
1894	Slavton, C. E	Sydney & Louisburg	Glace Bay, C.B., Canada.
1900	Slayton, F. T	St. Joseph & Grand Island	St. Joseph, Mo.
1889	Small, H. J	Southern Pacific	San Francisco, Cal.
1903	Smith, C. B	Boston & Maine	Boston, Mass.
1900	Smith, D. A	Boston & Maine	E. Somerville, Mass.
1893	Smith, F. B	N. Y. N. H. & H	New Haven, Conn.
1896	Smith, F. C	Amer. Loco. Co	Manchester, N. H.
1900	Smith, F. J	B. & O. S.-W	Chillicothe, Ohio.
1903	Smith George C	Maryland & Penna	Baltimore, Md.
1894	Smith, H. C	Los Angeles & Redondo	Los Angeles, Cal.
1892	Smith, John L	Buffalo, Rochester & Pittsburg	Du Bois, Pa.
1900	Smith, L. L	Chicago Great Western	Fort Dodge, Iowa.
1899	Smith, R. D	Burlington & Mo. River	Lincoln, Neb.
1891	Smith, Wm	Duluth, Missabe & Nor	Proctor Knott, Minn.
1902	Smith, Wm	N. Y. Cent. & Hudson River	Mott Haven, N. Y.
1869	Smith, W. T	Chesapeake & Ohio	Richmond, Va.
1903	Smitham, N. L	Texas Central	Walnut Springs, Tex.
1891	Soule, R. H		917 Seventh ave., New York City.
1899	Spillard, L. H		Apartado 447, City of Mexico.
1897	Spragge, Jos. R	Canadian Pacific	Toronto Junc., Ont., Can.
1901	Squire, W. C	Amer. Steel Foundries	St. Louis, Mo.
1898	Stansbury, C. M	Chicago & Eastern Illinois	Dalton Sta., Cook Co., Ill.
1874	Stevens, Geo. W		Elyria, Ohio.
1898	Stevenson, C. E	Mogyana	Campinos, San Paulo, Brazil, S. A.
1903	Stewart, A	Southern	Knoxville, Tenn.
1892	Stewart, Andrew F	Chesapeake & Ohio	Huntington, W. Va.
1900	Stewart, M. D.	Rio Gr., Sierra Madre & Pac	Ciudad Juarez, Mex.
1885	Stewart, O	Bangor & Aroostook	Oldtown, Maine.
1890	Stillman, H	Southern Pacific	Sacramento, Cal.
1896	Stocks, W. H		658 Rookery Bldg., Chicago, Ill.
1890	Studer, A. L	Colorado & Southern	Denver, Colo.
1901	Sullivan, J. J	Louisville & Nashville	Louisville, Ky.
1891	Summerskill, T. A	Vermont Central	St. Albans, Vt.
1892	Sumner, Eben T	Boston & Maine	East Cambridge, Mass.
1899	Suzuki, S	Kinshui	Moji, Japan.
1901	Swoyer, H	Louisville & Nashville	Louisville, Ky.
1899	Symington, T. H		702 Fidelity Bldg., Baltimore, Md.
1892	Symons, W. E	Gulf, Colorado & Santa Fe	Cleburne, Texas.
1902	Tabor, A. E	Montana Central	Great Falls, Mont.
1894	Taft, Wm. H	Boston & Albany	Allston, Mass.
1883	Tandy, H	Supt. Canadian Loco. Works	Kingston, Ont., Can.
1896	Tawse, Robt	Ann Arbor	Owosso, Mich.
1893	Taylor, C. M	Atchison, Topeka & Santa Fe	La Junta, Colo.
1900	Taylor, G. W		Chicago, Ill
1901	Taylor, H. D	Lehigh Valley	So. Bethlehem, Pa.
1896	Taylor, Jno	C. M. & St. P	Minneapolis, Minn.
1893	Taylor, Wm. H	N. Y., Susquehanna & Western	Stroudsburg, Pa.
1903	Teat, W. F	Atlanta, Knoxville & Northern	Blue Ridge, Ga.
1901	Templeton, W. S	Southern Pac. Co	San Luis Obispo, Cal.
1885	Thomas, C. F	Amer. Loco. Co	Richmond, Va.
1891	Thomas, H. T	Detroit & Mackinac	East Tawas, Mich.
1903	Thomas, J. G	Central R. R. of N. J	Ashley, Pa.
1892	Thomas, J. J., Jr	Seaboard Air Line	Savannah, Ga.
1883	Thomas, W. H		4230 Spruce st., Philadelphia, Pa.
1901	Thomas, W. T	Cleve. Cin. Chi. & St. Louis	Mt. Carmel, Ill.

JOINED.	NAME.	ROAD.	ADDRESS.
1890	Thompson, C. A		Morris Park, Long Island, N. Y.
1903	Thompson, E. B	Chicago & North-Western	Winona, Minn.
1896	Thompson, Geo	Union Pacific	Omaha, Neb.
1895	Thompson, W. T	80 Ludlow st	Yonkers, N. Y.
1902	Thompson, W. O	N. Y. Cent. & Hudson River	Oswego, N. Y.
1883	Thow, Wm	Government	Eveleigh, N. S. W.
1902	Thornton, Chas. J	United R'ys of Havana	Havana, Cuba.
1903	Tinker, J. H	Balto. & Ohio	Garrett, Ind.
1903	Todd, A. B	Southern California	San Bernardino, Cal.
1892	Todd, Louis C	Boston & Maine	Charlestown, Mass.
1898	Tollerton, W. J	Oregon Short Line	Salt Lake City, Utah.
1901	Toltz, Max		St. Paul, Minn.
1897	Tomlinson, J. J	Potosi & Rio Verde	San Luis Potosi, Mex.
1902	Tompkins, G. W	Nev.-Cal.-Oregon	Reno, Nev.
1893	Tonge, John	Minneapolis & St. Louis	Minneapolis, Minn.
1900	Tonkins, W. H	Lima	Callao, Peru, S. A.
1903	Torrey, F. A	Chicago, Bur. & Quincy	Chicago, Iowa.
1892	Townsend, Jos		Bloomington, Ill.
1896	Tracy, W. L	Southern	Atlanta, Ga.
1892	Traver, W. H		Rand Drill Co., Monadnock Block, Chicago, Ill.
1883	Tregelles, Henry		Care Norton, Megaw & Co., Rio de Janeiro, Brazil.
1892	Tremp, A. E		Matthews, Ind.
1890	Tuggle, S. R	Houston & Texas Central	Houston, Tex.
1903	Tuma, Frank	Erie	Buffalo, N. Y.
1903	Turnbull, A. G	Erie	Meadville, Pa.
1899	Turner, A	Lehigh Valley	South Easton, Pa.
1890	Turner, Calvin G	Phil. Balto. & Washington	Wilmington, Del.
1889	Turner, Chas. E	B. R. & P	Rochester, N. Y.
1886	Turner, J. S		Room 18, 160 Broadway, New York City.
1890	Turner, L. H	Pittsburg & Lake Erie	Pittsburg, Pa.
1886	Twombly, A. W	N. Y. N. H. & H	Taunton, Mass.
1883	Twombly, Fred M	N. Y. N. H. & H	Roxbury, Mass.
1887	Tynan, F. F		Hotel Trocha, Vidado, Havana, Cuba.
1890	Tyrrell, Thos. H		Tottenville, Staten Island, New York.
1889	Vail, A	Pennsylvania	Buffalo, N. Y.
1898	Van Alstyne, D.	Chicago Great Western	St. Paul, Minn.
1890	Van Brunt, G. E	Pennsylvania & N.-Western	Bellwood, Pa.
1896	Van Cleve, J. R	White Pass & Yukon	Skagway, Alaska.
1891	Vauclain, Samuel M	Baldwin Loco. Works	Philadelphia, Pa.
1898	Vaughan, H. H	Lake Shore & Mich. So	Cleveland, Ohio.
1903	Vernet, C. C	Western R'y of Havana	Havana, Cuba.
1896	Villasenor, Alberto		San Jose de Costa Rica, C. A.
1892	Vogt, A. S	Pennsylvania	Altoona, Pa.
1899	Vought, J. H	Lehigh Valley	South Bethlehem, Pa.
1892	Waitt, A. M		3 Phillipse Place, Yonkers, N. Y.
1900	Walker, E. S	Illinois Southern	Sparta, Ill.
1893	Walker, Henry E		Beyer, Peacock & Co., Gorton, Manchester, Eng.
1891	Wallis, J. M	Pennsylvania	Altoona, Pa.
1888	Wallis, Phillip	Long Island	Richmond Hill, L. I., N. Y.
1900	Walsh, F. O	A. & W. P., W. R'y of Ala	Montgomery, Ala.
1903	Walsh, J. F	Chesapeake & Ohio	Richmond, Va.
1874	Walsh, Thos	Louisville & Nashville	Howell, Ind.
1902	Walsh, W. C	Southern Indiana	Bedford, Ind.
1896	Walton, E. A	N. Y. Cent. & Hudson River	Corning, N. Y.
1887	Ward, C. F	C. St. P. M. & O	1517 Madison ave., Omaha, Neb.

JOINED.	NAME.	ROAD.	ADDRESS.
1883	Warren, Beriah		1619 Pennsylvania ave., St. Louis, Mo.
1882	Warren, W. B		1619 Pennsylvania ave., St. Louis, Mo.
1903	Waters, J. J	Mex. International	Ciudad Porfirio Diaz, Mex.
1902	Watson, Samuel	N. Y. Cent. & Hudson River	W. Albany, N. Y.
1883	Watts, Amos H	Cincinnati Northern	Van Wert, Ohio.
1887	Webb, F. W	London & North Western	Crewe, England.
1892	Weiss, C. P	American Loco. Co	Richmond, Va.
1886	Weisgerber, E. L	Baltimore & Ohio	Mt. Clare Shops, Baltimore, Md.
1900	Welch, C. H	Pearl & Leaf River	Hattiesburgh, Miss.
1903	Wellisch, Louis	Louisville & Atlantic	Richmond, Ky.
1896	West, A. T. (M. M.)		Tabor, Iowa.
1880	West, G. W	N. Y. O. & W	Middletown, N. Y.
1899	Westmark, H. O		144 N. Lake st., Aurora, Ill.
1903	Whetstone, John	Norfolk & Southern	Berkley, Va.
1885	White, A. M		20 Union ave., Schenectady, N. Y.
1894	White, E. T	Baltimore & Ohio	Mt. Clare, Baltimore, Md.
1901	White, W	Lake Erie & Western	Lima, Ohio.
1898	Whyte, F. M	N. Y. Central & Hudson River	New York City.
1899	Wiest, E. N	Man. & North-Eastern	Manistee, Mich.
1894	Wiggin, Chas. H	Boston & Maine	Malden, Mass.
1878	Wightman, D. A		Warren, R. I.
1900	Wilbur, I. N	Han. & St. Joseph	Hannibal, Mo.
1891	Wilcox, W. J	Mexican Central	Monterey, Mex.
1901	Wildin, G. W	C. R. R. of N. J	Jersey City, N. J.
1896	Williams, Alfred	Paulista	Paulista, Brazil, S. A.
1891	Williams, E. A	Canadian Pacific	Montreal, P. Q.
1903	Williams, F. W	Dela., Lack. & Western	Buffalo, N. Y.
1887	Wilson, G. F	Dela., Lackawanna & West	New York City.
1901	Wilson, W. H	Erie	Dunmore, Pa.
1900	Wirt, G	C. C. C. & St. L	Delaware, Ohio.
1900	Withers, A. B		304 So. Church st., Charlotte, N. C.
1903	Woodruff, S. N	Minn., St. P. & S. Ste. Marie	Gladstone, Mich.
1903	Worsdell, Wilson	North-Eastern	Gateshead-on-Tyne, Eng.
1901	Wright, R. V	Pittsburg & Lake Erie	Pittsburg, Pa.
1903	Yergens, W. F	Erie	Huntington, Ind.
1896	Yohn, C. R	H. & B. T. Mtn	Saxton, Pa.
1899	York, C. C	B. A. & Pac.	Estacon Junin, Buenos Ayres, Arg. Rep., S. A.
1902	Young, C. B	Chicago, Burlington & Quincy	Chicago, Ill.
1895	Young, W. H	Atlantic Coast Line	Savannah, Ga.
1898	Zerbee, F. J	C. C. C. & St. L	Bellefontaine, Ohio.

ASSOCIATE MEMBERS.

JOINED.	NAME.	ADDRESS.
1893	Baker, Geo. H	425 Summer ave., Brooklyn, N. Y.
1898	Basford, G. M	Morse Bldg., New York City.
1898	Bates, E. C	Lock Box 1544, Boston, Mass.
1903	Casey, F. A	271 Franklin st., Boston, Mass.
1890	Crossman, W. D	177 E. Randolph st., Chicago, Ill.
1883	Dean, F. W	55 State st., Boston, Mass.
1896	Fowler, Geo. L	53 Broadway, New York City.
1895	Goss, W. F. M	Purdue University, Lafayette, Ind.

JOINED.	NAME.	ADDRESS.
1839	Hill, John A.	80 Munn ave., E. Orange, N. J.
1899	Kneass, Strickland L.	Wm. Sellers Co., Ltd., Philadelphia, Pa.
1901	Lane, F. W.	*Railway Age*, Monadnock Bldg., Chicago, Ill.
1901	Player, John	American Loco. Co. Brooks Works, Dunkirk, N. Y.
1889	Pomeroy, L. R	General Electric Co., 44 Broad st., New York City.
1899	Smart, R. A.	B. F. Sturdevant Co., Boston, Mass.
1889	Smith, John Y.	Chicago, Ill.
1882	Smith, W. A.	Manhattan Bldg., Chicago, Ill.
1899	Street, Clement F.	Wellman-Seaver-Morgan Eng. Co., Cleveland, Ohio.
1903	Taylor, Jos. W.	667 Rookery Bldg., Chicago, Ill.

HONORARY MEMBERS.

JOINED.	NAME.	ROAD.	ADDRESS.
1883	Blackwell, Chas.		Mt. Lookout, Cincinnati, Ohio.
1869	Boon, J. M.		5117 Madison ave., Chicago, Ill.
1870	Bushnell, R.W.		Cedar Rapids, Iowa.
1879	Cooke, Allen		Danville, Ill.
1869	Coolidge, G. A.		Barnard ave., Watertown, Mass.
1870	Cooper, H. L.		Morgan Park, Ill.
1895	Coster, E. L.	Residence, Irvington on Hudson.	Broad Exchange Bldg., 25 Broad st., New York City.
1870	Divine, J. F	W. & Weldon	Wilmington, N. C.
1881	Eastman, A. G		Sutton, Que.
1871	Forney, M. N.		501 Fifth ave., New York City.
1872	Foss, J. M.	Cent. Vermont	St. Albans, Vt.
1885	Galloway, A	C. H. & D.	Cincinnati, Ohio.
1871	Hewitt, John		1323 So. Jefferson st., St. Louis, Mo.
1874	Jeffery, E. T.	Denver & Rio Grande	Denver, Colo.
1868	Johan, Jacob		515 So. State st., Springfield, Ill.
1868	Kinsey, J. I.	Lehigh Valley	Easton, Pa.
1873	Lewis, W. H.		Hoboken, N. J.
1878	Maglenn, Jas.	Seaboard Air Line	Raleigh, N. C.
1869	McKenna, John	I. D. & S. W.	Indianapolis, Ind.
1871	Miles, F. B.		Bement & Miles, Philadelphia, Pa.
1885	Paxson, L. B.	P. & R.	Reading, Pa.
1872	Philbric, J. W.		Waterville, Me.
1878	Pilsbury, Amos		Portland, Me.
1874	Place, T. W		Waterloo, Iowa.
1869	Richards, George		14 Auburn st., Roxbury, Mass.
1870	Robinson, W. A.		Hamilton, Ont.
1869	Sellers, Morris		Western Union Bldg., Chicago, Ill.
1868	Shaver, D. O.		Pittsburg, Pa.
1888	Sheppard, F. L.	Pennsylvania	Altoona, Pa.
1891	Sheer, J. M.		514 Seventh st., E. St. Louis, Ill.
1868	Sprague, H. N.		Jamestown, N. Y.
1869	Setchel, J. H.		Cuba, N. Y.
1875	Strode, Jas.		Elmira, N. Y.
1883	Sullivan, A. W.	Illinois Central	Chicago, Ill.
1869	Thompson, John		51 Lakewood Road, Newton Highlands, Mass.
1870	Towne, H. A.		54 S. Third st., Minneapolis, Minn.
1868	Wells, Reuben		Paterson, N. J.

PROCEEDINGS.

The Thirty-sixth Annual Convention of the American Railway Master Mechanics' Association convened at 10 o'clock A.M. on Wednesday, June 24, 1903, in the ballroom of the Grand Union Hotel, Saratoga, New York. President George W. West in the chair.

THE PRESIDENT: We have been spared through another year to meet again our old friends and welcome a large number of new members into the Association. To Him who has granted us these privileges we should be thankful, and I will ask the Rev. Joseph Carey, of the Episcopal Church of Saratoga Springs, to lead us in prayer.

The Rev. Joseph Carey offered prayer.

THE PRESIDENT: We expected to have Governor Odell with us this morning. He is not able to come, but has sent the following letter:

"It is with great regret that I must advise you of my inability to accept the invitation extended to me on behalf of your association to attend its convention. Your work is so intimately linked with the convenience, comfort and safety of the traveling public, and such strides have been made in the improvement of transportation facilities, largely through the instrumentality of the members of your association, that it would be a great pleasure to me to meet the members of your association and to express to them the obligations which the public is under to them."

While we very much regret the absence of Governor Odell this morning, we have with us the president of the village of Saratoga Springs, Mr. A. P. Knapp, whom I take pleasure in introducing to you:

PRESIDENT KNAPP: Mr. President, members of the American Railway Master Mechanics' Association, ladies and gentlemen: Under the spreading blacksmith tree, the village president stands.

[Laughter.] I think this is about the fifth time I have had the pleasure of greeting the Master Mechanics and your twin convention, the Master Car Builders; and it has occurred to me that possibly you may begin to think it is about time Saratoga Springs had a new president. I trust, if you feel that way, you will not mention it to the natives, among whom you may find one or two who will sympathize with your idea.

I find myself, Mr. President, in a somewhat unfortunate predicament this morning. I had prepared a skeleton, or a sort of a working plan, for a brief address, to inflict upon you this morning, but returning from an enforced and somewhat hurried trip, I find it has been mislaid, and I have been unable to locate it. The only material of the kind I seem to have at hand is an address delivered to the Undertakers' convention last week. I hardly think that would do to deliver before a meeting of the Master Mechanics. Simeon Ford, the celebrated hotel man and after-dinner speaker, said, in alluding to the great breakage of crockery in hotels, that he looked upon the hotel business and the crockery business as allied industries. I am not able to trace any alliance between this body and the undertakers — no joke intended, Mr. President.

I apprehend that your discussions and the purpose of your conventions are for the perfecting of plans which tend to hedge about the traveler certain safeguards that would naturally result in reducing the undertakers' business somewhat. I feel that, after being escorted to this presence, accompanied with the inspiring strains of your magnificent band, and after listening to the invocation of our dear friend, Dr. Carey, I ought to be able to say something; and I assure you that it gives me great pleasure, I feel it an honor, to again welcome you to your thirty-sixth annual convention, about to be held in this village. We feel that your coming to us, year after year, is a mark of approval of our village as a place for holding your conventions. You have occasionally, for geographical or other reasons, strayed away from us, but we felt all the time you were yearning for the flesh-pots of Saratoga Springs; and I can assure you the yearning is mutual. Your coming at the opening of the season is an inspiration and an incentive to us, after our long winter's sleep, to make the race of our lives for the elusive dollar which we are after here in Sara-

toga, and which we need very badly, I can assure you. The seasons are short and the winters mighty long; not quite so bad, however, as a certain place in Vermont, where the old residents said they had nine months of winter and three months "damn late in the fall." Pardon me for that expression; but our winters are long enough here.

I wish to express the hope, Mr. President and gentlemen of the Association, that this convention will be the most satisfactory in the history of your organization; that your entertainment will be altogether satisfactory and your stay in Saratoga thoroughly enjoyable; and we further hope that the time may come when your meeting with us will be a fixed annual event. I thank you for the privilege of addressing you gentlemen, and for your patient audience.

THE PRESIDENT: Mr. Knapp, we thank you for your kind words of welcome.

President West then delivered the following address:

Members of the American Railway Master Mechanics' Association, Ladies and Gentlemen:

In greeting you at Saratoga on this, our thirty-sixth anniversary, your president is somewhat in the position of a man who committed his speech to memory and when he faced his audience became so frightened that he could not collect his thoughts, but finally he began by saying, "Gentlemen and ladies, ladies and gentlemen: When I left home last night, God and I alone knew what I was going to say, and now God only knows."

Ever since we decided in December last to go to Mackinac, it has been my expectation that words of congratulation to you would be in order on how well the Westerners were going to take care of you; how our St. Louis friends would show our Saratoga friends how to handle a crowd and, incidentally, put six persons in three beds, with one bathtub and a promise in one small room, letter the beds A, B and C, and, knowing you to be master mechanics and master car builders, concluded there would be some master masons among you who would be able to arrange so trifling a matter as partitions, so that from this small room there might evolve three large double rooms, each with bath, at the moderate rate of $30 per day. Much to my dismay, on May 9, Secretary Taylor wired me: "Absolutely impossible for Weaver to handle our people."

Unless you have seen Montgomery and Stone in the "Wizard of Oz," portraying a western sandstorm in which a calf and the other inhabitants of a small Kansas town are taken up into the clouds and carried to another planet where they are converted into men of straw and tin, you will not be able fully to appreciate what we have escaped. We ought to

thank God and our efficient secretary that we were not carried to the Island of Mackinac and there obliged to hang on to pegs and cross-road signs, as the scarecrow and tin man in the "Wizard of Oz."

Seriously, the selection of a place for properly handling the two association meetings is not as trifling as you who have not been on the committee may think, and I can not impress the fact too strongly upon you all that the matter will need to be given far more consideration in the future than it has had in the past. That this convention was not held in the West, as many of our Western friends and quite a few of those in the East wished, is no fault of our officers or committee. When it was found impossible for us to go to Mackinac, Chicago came forward with a bid and a promise. When asked for a guarantee, the best they could do was two hundred rooms at the Auditorium Hotel, as headquarters, and one hundred additional rooms at the Great Northern Hotel. Niagara Falls could not take care of us at all in June. If it is desirable to go West next year, the committee should be given all the time from the adjournment of this meeting to the latest possible limit to select a place of adequate size for headquarters and exhibits.

The past year has been one of the most prosperous that the country has ever experienced. Notwithstanding that its enormous proportion presumably had been anticipated by many of the larger systems, a number of roads have had more business than could be handled, and an embargo had to be placed on several classes of freight. Within the past five years the trunk lines actually had agents soliciting freight in the territory of competing lines; during the past year they have had to refuse business. This shows the amount offered. The press of the country have tried to persuade the public that the trouble was with the motive power departments, or a lack of motive power or equipment. As a matter of fact, it was because nearly, if not quite all, the trunk lines lacked terminal facilities. It was no uncommon thing during the past winter to see miles and miles of trains, with the engine of the following train within coupling distance of the leading train waiting for orders to move, and instances have been cited to me of train crews reporting for duty immediately on arrival of train at destination, ready for work, having had the required amount of rest on the trip while sidetracked or awaiting orders. All these facts tend to prove that the freight congestion so much talked about was not due so much to lack of power and equipment as to operation or lack of terminal facilities. These conditions have proven more forcibly than could any committee of our Association, had it continued its investigation of cost of running high-speed trains, that the number of factors entering into the problem make it an unknown quantity, depending entirely on how much other traffic is delayed in keeping high-speed trains on time, and unless they are kept on time it is no credit to the system attempting it.

The per diem method or system of handling freight equipment demonstrated to many roads that it is wiser and better to look after the move-

ment of cars they owned than to build additional ones. The same rule, if applied to their locomotives, would give equally surprising results.

The anthracite strike in 1902 will go down in history as one of the most bitter and long-drawn battles between employers and employes this country has ever had. This fact is emphasized by the following statement recently made by Mr. Clarence S. Darrow, who fought the legal battle for the miners before the Anthracite Strike Commission:

"The great growth of trades unionism has caused its greatest peril. While it was remote from the masses of men, it was given little attention. But as it has grown strong and aggressive, reactionary forces must be expected to be called into operation to defeat its purposes and its ends. But still more dangerous to trades unionism is the modern tendency of the bodies themselves to ignore political and ethical questions of industry and government and direct their attention entirely to the betterment of wages and to the more immediate affairs that influence man. Any permanent advance in the condition of the workingman must come from two causes: First, a creation of natural conditions that will cause increased production; second, a natural condition that will cause more equitable distribution of wealth. After all, the prices of either labor or commodities can not long be kept up to an abnormal height, for natural laws must in the end prevail. Increasing the price of labor and then raising the price of the necessities of life to pay the increased wages is an artificial method that will in time fail."

For five months the coal business of the several anthracite coal carrying roads was practically shut down. The several roads referred to carried 23,120,238 tons less coal during the strike period than they did in the corresponding months of 1901; the miners lost a corresponding amount in wages, many branches of business suffered untold loss for want of fuel, and men well up in knowledge of the fuel situation prophesied that it would take two years at least to meet the requirements due to the shortage. In less than three months from the time of settlement we find the demand supplied and the storage of coal begun. It has proven what can be accomplished with our modern equipment when necessary. The several roads moved in the first four months following the settlement 5,624,828 tons in excess of any previous corresponding period. The New York, Ontario & Western, for example, moved 58,360 tons more coal in the three months following the strike settlement than ever before in the same period, with but two additional locomotives.

The anthracite strike enabled the bituminous coal companies to obtain a much higher price for their fuel and the result has been that the cost of fuel to operate our locomotives has been very materially increased.

It is strange, notwithstanding that this one item of expense on many roads equals the cost of repairs and wages of enginemen combined, it is given the least attention of anything entering into the performance-sheet figures. The wide fire-box engines lose a large percentage of their savings and other advantages in the extra coal used in cleaning fires and that

consumed while held on side tracks and at terminals. Undoubtedly, any road having one hundred locomotives in service can well afford to employ one man to every one hundred miles of road to give this question of fuel his entire attention. Like a great many other things that have been tried on railroads, the tonnage rating has in some cases been overdone, and in others, only on paper. Of all the attempts at rating the capacity of our locomotives, this tonnage basis has been the most abused; in some cases engines are going over the road with much less than their rated capacity, which is disastrous to the fuel side of the sheet; in other cases, the engines of same class and condition are given much more than their rated capacity, which is just as severe on the fuel charge.

On the road with which I am connected, by putting this matter of tonnage rating in the hands of one man, one class of our engines are now hauling from ninety-six to one hundred per cent of their rated capacity as against an average of eighty per cent before the system was first looked after by one man. The increased number of tons hauled by this one class of engines represents a saving of one train in five.

Our Association could do no better service for the railroads than to investigate the loss in fuel burned while engines are at rest on side tracks, ash pits and terminals. Much time and money have been spent in valve gears, exhaust pipes and smoke-box front end arrangements to reduce the quantity of coal consumed while engines are working steam, while practically nothing has ever been done to prevent the waste while engines are at rest. On a certain road making some experiments in the economy of coal consumed, with one locomotive, a saving was demonstrated of thirty per cent in fuel; twenty engines were afterward changed, and the saving fell to five per cent. The matter was fully investigated and it was found that the one engine had been given a train that kept it in nearly constant service; twenty engines could not be kept so employed, and the difference between the five per cent and thirty per cent was that consumed while at rest. As an illustration: One engine, with 18 by 24 inch cylinders, burning bituminous coal, with a lay-over from 10:45 A.M. to 4:30 P.M., in one case, burned sixty-one scoopfuls of coal, an average weight of seven pounds, or a total of 427 pounds, as against ten scoopfuls same weight, seventy pounds, all due to the manner in which the fire was cleaned and banked. The wider and larger our fire box and boilers the faster these proportions of waste increase, and this leads up to the question of economy in a great many departures that have been made in the past few years from the old slide valve properly balanced to the compound engine.

From all that can be learned, our improvements, so-called, do not accomplish all that is to be desired in the way of eliminating engine failures, and, after all, is not that about all that gives mechanical men a reputation, namely, the success we have in getting trains over the road on time? A nice indicator card to show our general manager, or a paper on fuel economy never pacifies him when the same engines that produced

them are giving up their trains occasionally or delaying them frequently by failures.

There seems to be a great diversity of opinion regarding the advantage or efficiency of the piston valve, and from all that can be learned the engine failures are not reduced on lines using them. In this connection have we not for the past few years paid too little attention to the one important factor in successful railroading, "engine failures," little things that affect the public and are seldom talked about in our meetings.

In my opinion, it will hold true on nearly all roads that twenty per cent of the engine failures represent eighty per cent of the cost, while the other eighty per cent of failures represent only about twenty per cent of the money damage, but represent a large proportion of perplexing delays. Many of these can be attributed to poor inspection, others to defects attending the high boiler pressure, such as broken water and lubricator glasses, etc., while quite a few are due to patent sanders and broken spring hangers.

Men connected with mountain roads, as I have been nearly all my life, will welcome the effort that is being made to meet the one serious defect in the automatic air brake, namely, the liability of heavy freight trains getting beyond control of the engineer descending long grades while train is being recharged. The Westinghouse people have an attachment connected with the engine that serves a valuable purpose in connection with the automatic brake as it relieves the friction from the locomotive tire while other brakes are in service, thus allowing the tire to remain cool and tight of wheel center and better adapted to check the speed of train when brakes are applied, which is only during the time train brakes are released while auxiliaries are being recharged.

Recent tests in stopping high-speed trains have demonstrated that the braking power of any metal used for braking diminishes as the heat increases, and we have found that engines equipped with the device referred to will hold trains down to the same speed, during all the time the brakes are being recharged, that had been attained at the time necessary to recharge.

Considerable progress has been made in the application of high-speed brakes, and both our brake companies have demonstrated that even more can be expected of the automatic brake than we have been getting, in its power to stop quick-moving trains. The two companies are working on entirely different lines to accomplish the same result, and it is to the interests of all the railroads in general that they lend all the assistance at their command to enable the brake companies to give us the best brake possible with the least expense or change.

This is certainly a high-speed age and only they that can attain it are in the race. Our visit to the Schenectady plant of the American Locomotive Company last June gave us a revelation, as we saw machine tools, of which we had duplicates, removing double the amount of metal that we were able to, with no more effort on machine or operator, simply using

a high-speed steel. Steelmakers, appreciating the conditions, have placed on the market several brands of high-speed steel, and, in my opinion, the railroads have not in years derived so much benefit from so little expense as we have during the past year, while additional tools have been hard to get and the output of our shops has depended entirely on the capacity of tools we had, which in many cases has been increased one hundred per cent by the use of this new tool steel.

The principal locomotive works turned out 3,582 locomotives during the year 1902, or over one locomotive every working hour in the year. Of this number 1,297 were engines rated as ninety tons or over and 742 were compounds.

It has been suggested that some representative form of membership be considered, either on a basis of total number of engines owned, or tractive power of engines owned. It would seem that the interests of the various roads would be best represented in the number of engines owned rather than tractive power, it being a simple unit and one requiring no calculation.

During the past year your association has been honored by a check from the Jerome Wheelock estate in the amount of $1,000 to establish a Jerome Wheelock fund. It is to be hoped that this fund will be increased so that the income from it, together with the additions from our proposed new form of membership, will enable us to conduct scientific investigations that will be a credit to the Association.

Attention was directed last year by President Waitt to the elaborate series of tests on locomotive draft appliances, which are being conducted at Purdue University by Professor Goss for the *American Engineer and Railroad Journal* at its own expense. The Association endorsed this commendable undertaking by authorizing the Executive Committee to assist in the work, which will be reported upon at this convention by a special committee. This research has already placed the study of stacks beside that of exhaust nozzles which were investigated by the Association in 1896. Much yet remains to be done in order to apply the best methods of design to large locomotives. The conclusions of Professor Goss with reference to stacks appear in the current number of the *American Engineer,* revealing valuable results already attained and indicating important lines for further investigation. I am also advised that arrangements have been made for installing a modern and complete testing laboratory at the World's Fair in St. Louis during 1904. Our Association will be asked to lend its aid, both financially and by a representative committee. It is hoped that the Association will take a broad view of this opportunity in the field of investigation, as it seems to be a most important field for extending the usefulness of the Association.

Our financial condition is not up to the standard of the Association. Our Secretary explains the increase in expenditures due to our printed Proceedings being unusually large and full of cuts and tabulated matter. In other words, we are giving too much for the money we get. We can

not afford to give less, and our only hope is that some means will be devised at this meeting to increase our receipts. We should have a live finance committee such as the Railroad Clubs, that enables them to hold nine meetings a year and furnish a lunch after each at a cost of $2 per year and have a large surplus at the end of the year.

A year ago we had 707 members, 653 of whom were active. Two former members have been reinstated, 95 new ones added. We have lost through transfer, death, resignation and non-payment of dues 52, leaving us 698 active and a total membership of 751.

Those who have met with us in the past and have crossed the river from whence no traveler returns are: John A. Quinn, W. C. Dallas, Edward Grafstrom, C. B. Hogsett, A. Hendee, Jacob Losey, W. L. Holman, active; E. F. Moore, associate, and William Swanston, S. A. Hodgman, George H. Prescott, honorary members.

In conclusion, it is a pleasure to mention the perfect understanding that exists between the officers of the Master Mechanics' and Master Car Builders' Associations and the hearty cöoperation with which they work together on all matters pertaining to the advancement of one or the other. The elective officers and appointed committees have made the duties of your President a pleasant task. The Association is to be congratulated on the work it is doing, and let me urge you one and all to participate in making this meeting a success.

THE PRESIDENT: Mr. Scott H. Blewett, of the Entertainment Committee, has an announcement to make.

MR. SCOTT H. BLEWETT: Ladies and Gentlemen: At the meeting of our committee, held in Buffalo in the latter part of last year, it was agreed that the number system of badges should be used for the convenience of the delegates and visitors and to facilitate registration. Members of the committee will go among the members of the Association and their guests and distribute these cards, the cards being intended for the use only of Master Mechanics, their families and their special friends. Please fill out these cards, and, as you pass through the door, members of the committee will give you the badge with the number on it. By a careful compliance with this request, you will assist us materially. I thank you for your attention.

THE PRESIDENT: It has been customary in the past to announce an intermission of five minutes, to allow those who do not desire to remain with us to leave the room. We shall be glad to have any who feel like it, remain with us during the entire session.

An intermission of five minutes was taken.

THE PRESIDENT: We will now resume the business of the convention, and the first business in order is the report of the Secretary.

To the President and Executive Committee of the American Railway Master Mechanics' Association:

The usual statements as to the membership and finances of the Association are given below:

ACTIVE MEMBERS.

Membership, June, 1902		653
Transferred to Honorary Membership	3	
Deaths	7	
Resignations	7	
Dropped for non-payment of dues	35	
		52
Total		601
New members received during the year	95	
Reinstated	2	
		97
Total		698

ASSOCIATE MEMBERS.

Membership, June, 1902	19
Deaths	1
Total	18

HONORARY MEMBERS.

Membership, June, 1902	35
Transferred from active	3
	38
Deaths	3
Total	35
Total: Active members	698
Associate members	18
Honorary members	35
	751

The active members transferred to the honorary list are: Messrs. Amos Pillsbury, James Strode and Charles Blackwell.

The members who resigned during the year were: Messrs. J. W. Cannaty, W. J. Hemphill, F. G. Lauer, J. T. Gordon, R. D. Sutherland, F. N. Hibbits and A. C. Hinckley.

The members who died during the year were: Messrs. John A. Quinn, C. B. Hogsett, W. C. Dallas, A. Hendee, Jacob Losey, W. L. Holman and Edward Grafstrom, active; E. F. Moore, associate, and William Swanston, George H. Prescott and S. A. Hodgman, honorary members.

The names of those who have been dropped from membership are as follows:

ASSOCIATE MEMBERS.

Richard Allin.	J. A. Barhydt.	J. Davis Barnett.
J. P. Bay.	A. J. Beltz.	Jno. Bonner.
T. L. Chubb.	Thos. Downing.	H. D. Galbraith.
J. R. Garrick.	J. Glaser.	A. W. Greenwood.
J. W. Hall.	T. Hatswell, Jr.	E. E. Hudson.
W. H. Hudson.	J. M. Keith.	D. M. King.
E. W. Knapp.	A. A. Maver.	W. A. Meagher.
A. Mitchell.	J. F. Morrison.	T. W. Newell.
H. Osborne.	H. J. Rainsford.	Frank Rearden.
W. T. Reed.	J. Ryder.	H. M. Sehrt.
J. C. Slater.	S. A. Steele.	G. W. Smith.
J. W. Witmer.	C. A. Ward.	

The new members received during the year are:

K. P. Alexander, M. M., Ft. Smith & Western R. R., Ft. Smith, Ark.
S. J. Anderson, M. M., A. K. & N. R. R., Blue Ridge, Ga.
H. W. Arnold, A. M. M., B. & O. R. R., Baltimore, Md.
P. G. Baker, M. M., Panama R. R., Colon, Columbia, C. A.
F. G. Benjamin, M. M., C. & N.-W. Ry., Clinton, Iowa.
W. J. Bennett, A. S. M. P., C. I. & L. Ry., Lafayette, Ind.
R. A. Billingham, G. M. M., P. S. & N. R. R., St. Marys, Pa.
Chas. A. Bingaman, M. E., Lima Loco. & Mach. Co., Lima, Ohio.
F. W. Brazier, A. S. R. S., N. Y. C. & H. R. R. R., New York city, N. Y.
Jas. Buchanan, Asst. Supt., American Loco. Company, Richmond, Va.
C. G. Bushmeyer, M. M., B. E. & T. Ry., Vernon, Texas.
W. L. Calvert, A. M. M., D. & R. G. R. R., Helper, Utah.
V. Z. Caracristi, C. D., Intercolonial Ry., Moncton, N. B.
F. L. Carson, M. M., G. C. & S. F. Ry., Cleburne, Texas.
G. I. Churchward, Loco. Supt., Great Western Ry., Swindon, England.
J. H. Clarke, M. M., Staten Isl. Rpd. Tran. Co., Clifton, S. I.
W. S. Clarkson, M. M., Nor. Pacific Ry., Livingston, Mont.
A. J. Cota, M. M., C. B. & Q. Ry., Chicago, Ill.
C. W. Cross, M. M., L. S. & M. S. Ry., Elkhart, Ind.
H. M. Curry, M. M., Northern Pacific Ry., Staples, Minn.
L. L. Dawson, M. M., Ill. Cent. R. R., McComb, Miss.
Geo. Dickson, G. F., Great Northern R. R., St. Paul, Minn.

M. Dunn, M. M., P. C. C. & St. L. Ry., Dennison, Ohio.
P. T. Dunlap, M. M., G. C. & S. F. Ry., Temple, Texas.
B. P. Flory, M. E., Lehigh Valley R. R., South Bethlehem, Pa.
F. W. Fritchey, M. M., Iowa & St. Louis R. R., Connellsville, Mo.
F. M. Fryburg, M. M., Great Northern Ry., Havre, Mont.
J. A. Gibson, M. M., C. C. C. & St. L. Ry., Urbana, Ill.
Edw. Grafstrom, M. E., A. T. & S. F. Ry., Topeka, Kan.
S. C. Graham, M. M., C. & N.-W. Ry., Lake City, Iowa.
W. S. Grandy, M. M., A. T. & S. F. Ry., Newton, Kan.
A. W. Harned, S. M. P., Chicago Short Line R. R., Cleveland, Ohio.
J. D. Harris, A. G. S. M. P., B. & O. R. R., Baltimore, Md.
W. C. Hayes, A. M. S., Erie Railroad Company, Meadville, Pa.
F. M. Hibbetts, M. E., Union Pacific R. R., Omaha, Neb.
F. P. Hickey, M. M., S. A. L. Ry., Raleigh, N. C.
C. R. Hillman, A. S. M. P., San Paulo Ry., San Paulo, Brazil.
W. P. Hobson, A. M. M., Ches. & Ohio Ry., Hinton, W. Va.
W. H. Hufman, M. M., C. & N.-W. Ry., Baraboo, Wis.
R. A. Johnson, M. M., Sonora Ry., Guaymas, Sonora, Mexico.
W. O. Johnson, M. M., Iowa Central Ry., Marshalltown, Iowa.
M. Jungling, M. M., T. T. & G. Ry., Kingwood, Ga.
J. B. Kilpatrick, A. S. M. P., C. R. I. & P. Ry., Chicago.
L. S. Kinnaird, M. M., C. A. & C. Ry., Mt. Vernon, Ohio.
A. R. Kipp, M. M., Wis. Cent. Ry., Fond du Lac, Wis.
H. P. Knight, M. M., B. & O. R. R., Newcastle Jct., Pa.
G. M. Knight, G. M. M., United Rys. of Havana, Havana, Cuba.
W. B. Leach, M. M., B. & A. R. R., Springfield, Mass.
H. A. Lyddon, S. Supt., Nor. Pac. Ry., Gladstone, Minn.
D. R. MacBain, M. M., Mich. Cent. R. R., Jackson, Mich.
T. M. Markle, M. M., Pac. Coast Ry., San Luis Obispo, Cal.
H. C. Manchester, A. M. M., B. & M. R. R., Mechanicsville, N. Y.
H. C. May, M. M., C. C. C. & St. L. Ry., Louisville, Ky.
T. McHattie, M. M., Grand Trunk Ry., Montreal, Can.
J. T. McGrath, M. M., Grand Trunk Ry., Port Huron, Mich.
W. G. Menzel, S. M. P., Wis. Cent. Ry., Fond du Lac, Wis.
W. J. Miller, M. M., St. Louis South-Western, Tyler, Texas.
Wm. Moir, Shop Supt., Northern Pac. Ry., S. Tacoma, Wash.
F. B. Morrison, M. M., Panama R. R., Panama, C. A.
H. K. Mudd, M. M., C. R. & M. Ry., Richmond, Ind.
J. C. Nolan, M. M., Arkansas Southern Ry., Ruston, La.
G. B. Nutt, C. M. E., Queensland Govt. Ry., Brisbane.
H. E. Passmore, S. M. P., Detroit Southern Ry., Springfield, Ohio.
W. M. Paul, M. M., G. H. & H. R. R., Galveston, Texas.
D. M. Pearsall, M. M., A. C. L. Railroad, Florence, S. C.
J Piccioli, M. M., Colo. & Wyoming Ry., Pueblo, Colo.
J. A. Pilcher, M. E., N. & W. Ry., Roanoke, Va.
E. W. Pratt, Esq., M. M., C. & N.-W. Ry., Mo. Valley, Iowa.

W. H. Prendergast, M. M., Cent. of Ga. Ry., Columbus, Ga.
W. L. Reid, A. S., Amer. Loco. Co., Dunkirk, N. Y.
W. W. Rickard, M. M., Cananea Cop. Co's Ry., La Cananea, Sonora, Mex.
J. M. Robb, S. M. P., Can. Nor. R. R., Winnipeg, Manitoba.
R. H. Rogers, Loco. Inspector, B. & O. R. R., Richmond, Va.
W. H. Russell, M. M., So. Pac. Company, Oakland, Cal.
S. Shepard, M. M., "Soo" Line, Enderline, N. D.
G. C. Smith, M. M., Maryland & Penna. R. R., Baltimore, Md.
Wm. Smith, G. F., N. Y. C. & H. R. R. R., Jersey Shore, Pa.
A. Stewart, M. M., Southern Ry., Knoxville, Tenn.
J. G. Thomas, M. M., Cent. R. R. of N. J., Ashley, Pa.
E. B. Thompson, M. M., C. & N.-W. Ry., Mason City, Iowa.
C. J. Thornton, Loco. Supt., United Rys. of Havana, Havana, Cuba.
J. H. Tinker, M. M., B. & O. R. R., Garrett, Ind.
A. B. Todd, M. M., So. Cal. Ry., San Bernardino, Cal.
G. W. Tompkins, S. M. P., Nev. Cal. & Ore. Ry., Reno, Nev.
Frank Tuma, M. M., Erie Railroad Company, Buffalo, N. Y.
C. C. Vernet, S. M. P., Western Rys., Havana, Cuba.
J. F. Walsh, S. M. P., Ches. & Ohio Ry., Richmond, Va.
Sam'l Watson, M. M., N. Y. C. & H. R. R. R., W. Albany, N. Y.
L. Wellisch, M. M., Louisville & Atlantic Ry., Richmond, Ky.
Jno. Whetstone, A. S. M. P., Nor. & So. R. R., Berkley, Va.
F. W. Williams, M. M., D. L. & W. Ry., Buffalo, N. Y.
S. N. Woodruff, M. M., "Soo" Line, Gladstone, Mich.
Wilson Worsdell, C. M. E., North-Eastern Ry., Gateshead-on-Tyne, Eng.
W. F. Yergens, M. M., Erie Railroad Company, Huntington, Ind.
C. B. Young, M. E., C. B. & Q. Ry., Chicago.

The receipts and expenses for the year ending June 12, the date of closing the books preparatory to this report, were as follows:

RECEIPTS.

To dues collected from members	$2,930 00
To sale of Proceedings	1,076 83
To sale of index of Proceedings	45 00
To Treasurer	800 00
Total	$4,851 83

EXPENSES.

Paid electros, zinc cuts, etc.	$ 148 96
" exchange	12 55
" expenses, committees	74 01
" expenses, convention, 1902	64 12
" expressage	119 95
Carried forward	$ 419 59

Brought forward	$ 419 59
Paid office rent	171 36
" office supplies	12 60
" printing	2,286 68
" reporting convention, 1902	165 00
" salary, Secretary, June 20, 1902, to June 20, 1903, including clerk	1,200 00
" stamps and stamped envelopes	224 86
" surety bonds, Secretary	6 80
" telegrams	5 62
" tracings, blue-prints, etc	230 81
" Treasurer	128 51
	$4,851 83

There are no unpaid bills against the Association, except for some of the reports received and printed after the books were closed. The money belonging to the Association is in the hands of the Treasurer.

The unpaid dues amount to $830. A detailed statement of the members in arrears is attached hereto for the information of the members.

A detailed statement of the dues collected from members during the year is attached hereto as a part of this report.

SCHOLARSHIPS.

Regarding the scholarships of this Association at Stevens Institute of Technology, Mr. Edward A. Quigg graduates this year, consequently there will be one vacancy next year. The other three scholarships are held by Lindsay B. Fry, J. E. Ennis and George I. Branch.

Jos. W. Taylor, *Secretary.*

DETAILS OF DUES COLLECTED FROM MEMBERS.

June	23	G. S. Allen.....	$5.00
"	23	G. E. Branch...	5.00
"	23	D. Brown	5.00
"	23	J. A. Carney...	5.00
"	23	J. J. Connoly...	5.00
"	23	M. S. Curley...	5.00
"	23	M. R. Davis....	5.00
"	23	S. M. Dolan....	5.00
"	23	T. M. Feeley...	5.00
"	23	Thos. Fildes ...	5.00
"	23	John Foulk	10.00
"	23	Wm. Garstang..	5.00
		Carried forward...$	65.00

		Brought forward...$	65.00
June	23	F. A. Givin....	5.00
"	23	H. D. Gordon..	5.00
"	23	Geo. A. Hancock	5.00
"	23	G. H. Haselton.	5.00
"	23	J. A. Hill......	5.00
"	23	W. L. Holman.	5.00
"	23	A. H. Jackson..	5.00
"	23	J. L. Lawrence.	5.00
"	23	W. W. Lowell..	5.00
"	23	Jno. Mackenzie.	5.00
"	23	J. H. McConnell	5.00
		Carried forward...$	120.00

		Brought forward...$	120.00
June	23	W. J. McLean..	5.00
"	23	C. J. McMasters	5.00
"	23	E. A. Miller....	5.00
"	23	G. A. Miller....	10.00
"	23	S. W. Miller...	5.00
"	23	P. H. Minshull.	5.00
"	23	J. G. Neuffer...	5.00
"	23	J. O. Pattee....	5.00
"	23	C. H. Quereau..	5.00
"	23	C. E. Rettew...	5.00
"	23	O. H. Reynolds.	5.00
"	23	Frank Robinson	10.00
"	23	C. B. Royal....	5.00
"	23	G. W. Sidell...	10.00
"	23	L. A. Shepard..	5.00
"	23	F. C. Smith....	5.00
"	23	Wm. Smith....	5.00
"	23	W. T. Smith...	5.00
"	23	O. Stewart.....	5.00
"	23	E. T. Sumner..	5.00
"	23	H. Swoyer.....	10.00
"	23	T. A. Summer-skill	5.00
"	23	W. H. Thomas.	5.00
"	23	W. T. Thompson	5.00
"	23	L. T. Todd.....	10.00
"	23	Jno. Tonge.....	5.00
"	23	A. M. Waitt...	5.00
"	23	F. O. Walsh....	5.00
"	23	A. H. Watts....	5.00
"	23	G. W. West....	5.00
"	23	G. Wirt........	5.00
"	23	R. V. Wright...	5.00
"	23	E. P. Mallinson	5.00
"	23	J. F. Deems....	10.00
"	23	J. A. Gibson...	5.00
"	23	H. C. Manchester	5.00
"	23	C. J. Thornton..	5.00
"	23	Sam'l Watson..	5.00
"	23	E. T. White....	5.00
"	23	W. L. Gilmore.	5.00
"	23	F. F. Hildreth..	5.00
		Carried forward...$	355.00

		Brought forward...$	355.00
July	3	Geo. James.....	5.00
"	3	J. A. Egan.....	5.00
"	3	Geo. W. Taylor	5.00
"	3	Jas. Ashworth..	5.00
"	3	T. M. Gibb.....	5.00
"	3	Jno. Howard...	5.00
"	3	Geo. Donahue..	5.00
"	3	H. C. Smith....	5.00
"	3	A. Sauter	5.00
"	3	S. Suzuki	5.00
"	3	R. F. Kilpatrick	5.00
"	7	A. C. Hone.....	5.00
"	7	J. B. Barnes....	5.00
"	7	C. W. Cross....	5.00
"	7	H. H. Vaughan	5.00
"	7	L. H. Turner...	5.00
"	7	A. B. Minton...	5.00
"	7	T. S. Lloyd....	5.00
"	7	J. W. Marden..	5.00
"	7	W. H. Taylor..	5.00
"	7	A. W. Belcher..	5.00
"	7	Peter H. Peck..	5.00
"	9	G. W. Cushing.	5.00
"	9	F. F. Gaines....	5.00
"	9	G. W. Rhodes..	5.00
"	9	Willard Kells..	5.00
"	9	LeGrand Parish	5.00
"	9	W. C. Arp......	5.00
"	9	J. E. Keegan...	5.00
"	9	R. J. Gross....	5.00
"	9	H. L. Leach....	5.00
"	9	C. F. Street....	5.00
"	9	H. F. Ball......	5.00
"	9	Wm. Jenkins...	5.00
"	9	Jno. J. Monahan	5.00
"	9	S. F. Prince, Jr.	5.00
"	9	L. R. Pomeroy.	5.00
"	9	Chas. J. Cooper	5.00
"	9	W. Laing......	5.00
"	9	Philip Wallis...	5.00
"	9	W. P. Appleyard	5.00
"	9	E. A. Walton..	5.00
		Carried forward...$	565.00

		Brought forward...$	565.00
July	9	H. S. Hayward	5.00
“	9	W. H. V. Rosing	5.00
“	9	L. C. Noble....	5.00
“	9	Wm. Laing.....	5.00
“	10	J. S. Chambers.	5.00
“	10	E. S. Marshall.	5.00
“	10	J. L. Greatsinger	5.00
“	10	Thos. Millen...	5.00
“	10	P. Maher	5.00
“	10	S. L. Kneass...	5.00
“	10	G. W. Wildin..	5.00
“	10	P. Leeds	5.00
“	10	J. E. Sague....	5.00
“	10	P. T. Lonergan	5.00
“	10	Jas. Buchanan..	5.00
“	10	F. C. Cleaver...	5.00
“	10	Chas. A. Bingaman	5.00
“	10	W. L. Reid.....	5.00
“	10	F. M. White...	5.00
“	10	F. Hedley......	5.00
“	10	W. H. Wilson..	5.00
“	11	A. B. Johnson..	5.00
“	11	S. M. Vauclain.	5.00
“	11	Beriah Warren.	5.00
“	11	Chas. H. Davis.	5.00
“	11	T. W. Place....	5.00
“	11	A. Forsythe....	5.00
“	11	B. Haskell.....	5.00
“	11	F. W. Dean....	5.00
“	11	F. A. Delano...	5.00
“	15	E. M. Herr.....	5.00
“	15	W. J. Wilcox..	5.00
“	15	R. H. Soule....	5.00
“	15	Max Toltz	5.00
“	15	D. A. Wightman	5.00
“	15	C. F. Chase....	5.00
“	15	C. Phillips	5.00
“	15	R. D. Smith....	5.00
“	15	J. R. Groves...	5.00
“	15	Henry Elliott..	5.00
		Carried forward...$	765.00

		Brought forward...$	765.00
July	15	Sam'l Higgins..	5.00
“	15	Geo. N. Riley..	5.00
“	15	W. B. Warren.	5.00
“	15	E. Ryan	5.00
“	15	F. W. Morse...	5.00
“	15	J. Hainen	5.00
“	15	W. S. Hancock.	5.00
“	15	W. M. Kumner.	5.00
“	15	F. W. Brazier..	5.00
“	15	Wm. McIntosh.	5.00
“	15	J. W. Addis....	5.00
“	15	C. B. Young...	5.00
“	15	P. H. Hammet.	5.00
“	17	Geo. Gibbs	5.00
“	17	Henry Bartlett.	5.00
“	17	C. H. Howard..	5.00
“	17	Ed. E. Davis...	5.00
“	17	Jos. E. Irwin...	5.00
“	17	Jno. Taylor ...	5.00
“	17	Amos Turner ..	5.00
“	17	Geo. T. Neubert	5.00
“	17	A. G. Leonard..	5.00
“	17	C. R. Yohn.....	5.00
“	17	B. M. Boldridge	15.00
“	17	T. B. Purves, Jr.	5.00
“	17	A. L. Studer...	5.00
“	17	Wm. Smith (D. M. & N.)....	5.00
“	19	T. E. Adams...	5.00
“	19	S. P. Bush.....	5.00
“	19	T. E. Keyworth	5.00
“	19	M. J. Drury....	5.00
“	19	Jno. Hair	5.00
“	19	W. F. M. Goss.	5.00
“	19	R. C. Blackall..	5.00
“	19	F. H. Clark....	5.00
“	19	R. A. Smart....	5.00
“	19	A. J. Pitkin....	5.00
“	19	I. N. Wilbur...	5.00
“	19	Geo. A. Bruce..	5.00
“	22	P. E. Garrison.	5.00
“	22	Chas. E. Turner	5.00
“	22	H. M. Pflager..	5.00
		Carried forward...$	985.00

		Brought forward...	$ 985.00
July	22	A. J. Dunn.....	5.00
"	22	C. A. Delaney..	5.00
"	22	Wm. O'Herin..	5.00
"	22	Chas. H. Barnes	5.00
"	22	W. B. Gaskins.	5.00
"	22	F. J. Smith.....	5.00
"	22	J. S. Turner...	5.00
"	22	H. J. Small....	5.00
"	22	Henry Schlacks	5.00
"	22	C. H. Hogan...	5.00
"	22	C. M. Mendenhall	5.00
"	22	Jno. A. Pilcher.	5.00
"	22	Allen Vail	5.00
"	22	W. H. Stocks...	5.00
"	25	Tracy Lyon ...	5.00
"	25	Jno. S. Cook...	5.00
"	25	D. Van Alstine.	5.00
"	25	A. Sinclair	5.00
"	25	Jas. McNaughton	5.00
"	25	Jno. W. Cloud..	5.00
"	25	Robt. Moran ...	5.00
"	25	J. R. VanCleve.	5.00
"	25	C. M. Babcock.	5.00
"	25	L. M. Butler...	5.00
"	25	J. A. Graham...	5.00
"	25	J. F. Dunn.....	5.00
"	25	J. R. Bissett....	10.00
"	25	F. A. Chase....	5.00
"	25	R. O. Cumback.	5.00
"	25	C. G. Turner...	5.00
"	25	W. H. Brehm..	5.00
"	25	G. M. Basford..	5.00
"	25	W. J. McLeish.	5.00
"	25	F. T. Slayton...	5.00
"	25	L. B. Rhodes...	5.00
"	28	I. W. Fowle....	5.00
"	28	Wm. Renshaw.	5.00
"	28	J. M. Wallis...	5.00
"	28	Mord Roberts..	5.00
"	28	A. R. Kipp.....	5.00
"	28	Frank Singer ..	5.00
		Carried forward...	$1,195.00

		Brought forward...	$1,195.00
July	28	J. P. Nolan....	5.00
"	28	Jas. Kennedy...	5.00
"	28	Lester I. Knapp	5.00
"	28	Geo. L. Fowler.	5.00
"	30	F. E. Davisson..	5.00
"	30	A. E. Taber....	5.00
"	30	D. Hawksworth	5.00
"	30	Jno. Horrigan..	5.00
"	30	H. T. Thomas..	5.00
"	30	A. E. Mitchell..	5.00
"	31	C. H. Seabrooke	5.00
"	31	J. K. Brassell..	5.00
"	31	C. S. Morse....	5.00
Aug.	1	C. R. Hillman..	5.00
"	1	Willard A.Smith	5.00
"	1	Jno. J. Ellis....	5.00
"	1	Eli Punshon....	5.00
"	6	F. Hufsmith...	5.00
"	6	Jno. Hayden ...	5.00
"	6	Geo. L. Dickson	5.00
"	6	John Gill.......	5.00
"	6	W. K. Christie.	5.00
"	6	F. J. Cole......	5.00
"	6	W. S. Morris...	5.00
"	6	J. C. Nolan....	5.00
"	6	C. M. Stansberry	5.00
"	6	W. J. Tollerton	5.00
"	6	T. A. Foque....	5.00
"	6	H. G. Hudson..	5.00
"	6	S. K. Dickerson	5.00
"	6	H. A. Childs...	5.00
"	8	J. W. Fogg....	5.00
"	8	H. D. Taylor...	5.00
"	8	A. J. Cota......	5.00
"	8	Geo. Dickson...	5.00
"	8	A. L. Beattie...	10.00
"	12	W. A. Nettleton	5.00
"	12	T. W. Heintzelman	5.00
"	12	F. W. Webb....	5.00
"	12	W. H. Taft....	5.00
"	12	Wm. Fuller....	5.00
		Carried forward...	$1,405.00

		Brought forward...	$1,405.00
Aug.	12	J. J. Tomlinson	5.00
"	16	David Holtz ..	5.00
"	16	Jno. Cullinan...	5.00
"	16	Ben Johnson ..	5.00
"	16	Geo. R. Henderson	5.00
"	16	T. W. Demarest	5.00
"	21	W. Cross	5.00
"	21	W. H. Traver..	5.00
"	21	E. D. Bronner..	5.00
"	21	J. J. Ryan......	5.00
"	21	E. H. Emerson.	5.00
"	21	P. H. Murphy..	5.00
"	21	J. J. Sullivan...	5.00
"	21	B. F. Marshall.	5.00
"	21	W. C. Walsh...	5.00
"	21	E. S. Walker...	5.00
"	21	Owen Clarke...	5.00
"	26	W. H. Lewis...	5.00
"	26	F. J. Leigh.....	5.00
"	26	W. N. Best....	5.00
"	26	F. B. Griffith...	5.00
"	26	H. S. Bryan....	5.00
"	26	E. L. Weisgerber	5.00
"	26	F. D. Casanave.	5.00
"	26	J. D. Harris....	5.00
"	26	Alfred Lovell..	5.00
"	26	W. S. Templeton	5.00
"	26	D. S. Cooper...	5.00
"	26	S. T. Balkam...	5.00
"	28	J. W. Hill......	5.00
"	28	A. Beckert	5.00
"	29	Geo. D. Brooke.	5.00
"	29	Wilbur Greene.	5.00
Sept.	6	N. Frey	10.00
"	6	W. F. Post.....	5.00
"	6	W. Augustus...	5.00
"	6	F. M. Whyte...	5.00
"	6	W. F. Dixon...	5.00
"	6	V. Z. Caracristi.	5.00
"	6	Geo. F. Wilson.	5.00
		Carried forward...	$1,610.00

		Brought forward...	$1,610.00
Sept.	6	Peter C. Rusch.	5.00
"	6	W. T. Thomas.	5.00
"	15	J. J. Impett....	5.00
"	15	G. S. McKee...	5.00
"	15	E. T. James....	5.00
"	15	C. H. Prescott..	5.00
"	15	Chas. H. Wiggin	5.00
"	15	Jno. C. Glass...	5.00
"	15	Jos. E. Gould..	5.00
"	19	W. E. Killen...	5.00
"	19	J. J. Impett....	5.00
"	19	Wm. E. Knight	5.00
"	25	D. F. Crawford	5.00
"	25	D. O'Leary.....	5.00
"	25	J. E. Muhlfield.	5.00
"	25	A. G. Machesney	5.00
"	30	Robt. Gould ...	5.00
"	30	L. T. Canfield..	5.00
"	30	C. A. Seley.....	5.00
"	30	H. M. C. Skinner	5.00
Oct.	6	C. E. Stevenson	5.00
"	6	Edw. C. Bates..	5.00
"	6	J. N. Sanborn..	5.00
"	6	J. H. Manning.	5.00
"	10	J. F. Walsh....	5.00
"	10	H. Lopez Aldana	5.00
"	11	Jas. Hardie.....	5.00
"	11	Edw. N. Weist.	5.00
"	11	W. H. Nuttall..	5.00
"	11	Jno. Medway...	5.00
"	11	W. O. Lucas...	5.00
"	11	T. S. Beauclerk	5.00
"	11	H. D. Ellis.....	5.00
"	14	E. A. Williams.	5.00
"	14	V. B. Lang.....	5.00
"	14	R. C. Esson....	10.00
"	20	L. S. Randolph.	5.00
"	20	W. W. Atterbury	5.00
"	20	A. S. Vogt.....	5.00
		Carried forward...	$1,810.00

		Brought forward...	$1,810.00
Oct.	20	A. W. Gibbs....	5.00
"	20	Wm. Forsyth...	5.00
"	23	W. White	5.00
"	27	Henry E. Walker	10.00
"	27	Louis Greaven..	5.00
Nov.	1	G. B. Nutt......	5.00
"	5	Frank Slater...	5.00
"	5	T. A. Lawes...	5.00
"	5	H. T. Bentley..	5.00
"	7	A. J. Cromwell.	5.00
"	7	J. J. Casey.....	5.00
"	7	J. B. Michael...	5.00
"	7	C. M. Taylor...	5.00
"	10	D. C. Courtney.	5.00
"	10	W. Sinnott	5.00
"	10	F. W. Lane....	5.00
"	10	Thos. Jennings.	5.00
"	15	W. J. Hemphill	5.00
"	15	J. B. Morgan...	5.00
"	15	A. E. Manchester	5.00
"	19	C. D. Hilferty..	5.00
"	19	R. P. Blake....	5.00
"	19	W. E. Symons.	5.00
"	19	Geo. W. Stevens	5.00
"	19	J. P. McCuen..	5.00
"	19	I. N. Kalbaugh.	5.00
"	21	J. A. Edwards..	5.00
"	21	J. C. Haggett..	5.00
"	21	W. O. Thompson	5.00
"	21	B. H. Hawkins.	5.00
"	21	F. B. Smith....	5.00
"	21	W. L. Austin...	5.00
"	24	F. M. Twombly	5.00
"	24	H. Tandy	5.00
"	24	Geo. Gurry	5.00
"	24	Isaac W. Clark.	5.00
"	28	J. M. Robb.....	5.00
"	28	P. D. Plank....	5.00
"	28	W. H. Richmond	5.00
Dec.	4	T. McNabb	5.00
		Carried forward...	$2,015.00

		Brought forward...	$2,015.00
Dec.	4	J. N. Barr.....	5.00
"	8	Jno. Lahey.....	5.00
"	8	W. H. Marshall	5.00
"	8	M. K. Barnum.	5.00
"	8	Jas. Macbeth...	5.00
"	8	W. R. McKeen, Jr.	5.00
"	8	M. Dunn	5.00
"	8	W. P. Hobson..	5.00
"	13	Jas. W. Cross..	5.00
"	13	R. F. Hoffman.	5.00
"	13	F. B. Morrison.	5.00
"	13	S. F. Forbes....	5.00
"	13	Geo. Gilmour...	10.00
"	22	W. D. Robb....	5.00
"	22	Geo. W. Kenney	5.00
"	22	Chas. Muchnic..	5.00
"	22	H. A. Gillis....	5.00
"	22	J. M. Davis....	5.00
"	22	G. A. Ferguson	5.00
"	22	H. W. Hibbard.	5.00
"	22	F. Mertsheimer.	5.00
"	22	Thos. Aldcorn..	5.00
"	26	J. R. Slack.....	5.00
"	26	C. H. Cory.....	5.00
"	30	W. Buchanan..	10.00
"	30	H. C. May......	5.00
"	30	Oscar Antz	5.00
"	31	Jas. Fitzmorris.	5.00
Jan.	9	Henry Tregelles	5.00
"	9	Jno. Hopwood..	5.00
"	9	Jos. Roberts....	5.00
"	9	Geo. W. Thompkins	5.00
"	9	Chas. F. Baker.	5.00
"	9	C. J. Mellin....	5.00
"	9	S. B. Clay......	5.00
"	9	Jos. R. Spragge	5.00
"	14	S. J. Dillon....	5.00
"	14	C. P. Weiss....	5.00
"	20	S. T. Park.....	5.00
"	22	Thos. Roope ..	5.00
		Carried forward...	$2,225.00

		Brought forward...	$2,225.00
Jan.	27	G. J. Churchward	5.00
"	27	W. C. Squire...	5.00
Feb.	9	M. J. Rodgers..	5.00
"	9	Jno. Harrison..	5.00
"	9	A. T. West.....	5.00
"	9	D. J. Justice....	5.00
"	19	Louis Wellisch.	5.00
"	19	H. G. Beckhold.	5.00
"	19	R. H. Briggs...	5.00
"	21	F. W. Fritchey.	5.00
Mar.	7	Louis Greaven..	5.00
"	7	Thos. Paxton..	5.00
"	7	J. I. Krauss....	5.00
"	13	Sam'l Shepard..	5.00
"	13	Chas. DeGress.	5.00
"	20	S. R. Tuggle....	5.00
"	20	H. T. Peyton...	5.00
"	20	T. E. Cannon...	5.00
"	20	F. J. Zerbee....	5.00
"	20	J. H. Pennington	5.00
"	20	W. C. Ennis....	5.00
"	20	T. H. Symington	5.00
"	20	J. J. Ewing	5.00
"	20	I. N. Woodruff.	5.00
"	20	J. F. Deems....	5.00
"	20	Thos. Walsh...	5.00
"	20	J. W. Roberts..	5.00
"	20	Jno. C. Homer.	5.00
"	20	Robt. Quayle...	5.00
"	20	Mason Rickert.	5.00
"	20	J. Potton.......	5.00
"	20	A. L. Moler....	5.00
"	20	N. W. Sample..	5.00
"	20	R. M. Galbraith	5.00
"	20	J. T. Patterson.	5.00
"	20	Geo. W. Butcher	5.00
"	25	A. McCormick.	10.00
"	25	T. M. Conlon..	5.00
"	25	G. T. Mackinnon	5.00
"	25	W. F. Bradley..	5.00
		Carried forward...	$2,430.00

		Brought forward...	$2,430.00
Mar.	25	Jno. L. Smith..	5.00
"	25	F. N. Risteen...	5.00
"	25	C. K. Bowles...	5.00
"	25	J. B. Johnson..	5.00
"	25	Jos. Billingham.	5.00
"	25	F. T. Hyndman	10.00
"	25	Wm. Hassman..	5.00
"	25	J. W. Connaty.	5.00
"	25	F. E. Place.....	5.00
"	25	C. R. Ord......	5.00
"	30	W. P. Orland..	5.00
"	30	H. M. Minto...	5.00
Apr.	4	Jacob Christopher	5.00
"	4	C. E. Fuller....	5.00
"	10	R. E. French...	5.00
"	10	H. Stillman....	5.00
"	11	C. E. Slayton...	5.00
"	20	Jas. Marchbanks	5.00
"	20	Harry Pearse...	5.00
"	20	D. J. Redding..	5.00
"	20	E. V. Sedgwick	5.00
"	20	C. A. Thompson	5.00
"	20	T. W. Macfarlane	5.00
"	20	H. Delaney	5.00
"	20	A. L. Humphrey	5.00
"	20	M. D. Stewart.	5.00
"	24	A. W. Twombly	5.00
"	24	Wm. Lachlin...	5.00
"	24	Geo. Lindoff....	15.00
May	1	F. W. Williams	5.00
"	13	Geo. Gilmour...	5.00
"	13	F. G. Brownell.	5.00
"	13	A. Villasenor...	5.00
"	13	Jas. M. Dow...	5.00
"	13	C. F. Thomas..	5.00
"	13	G. R. Joughins.	5.00
"	13	Jno. Hawthorne	5.00
"	13	W. E. Amann..	10.00
"	13	Chas. Lindstrom	5.00
"	13	R. P. C. Sanderson	5.00
		Carried forward...	$2,650.00

		Brought forward...	$2,650.00
May	13	W. L. Calvert..	5.00
"	13	F. G. Benjamin.	5.00
"	14	J. T. McGrath..	5.00
"	14	Alex Stewart...	5.00
"	23	W. L. Tracy....	5.00
"	23	Jas. Cunningham	5.00
"	23	Rich. English...	10.00
"	23	P. G. Baker....	5.00
"	23	L. R. Johnson..	5.00
"	23	T. R. Browne..	5.00
"	23	C. T. McElvaney	5.00
"	26	Alex. B. Todd.	5.00
"	26	J. C. Shields...	5.00
June	2	J. F. Rotheram.	15.00
"	2	C. F. Lape.....	5.00
"	2	Jas. Carr	5.00
"	2	Thos. Rumney..	5.00
"	2	Jas. Kennedy...	5.00
"	2	H. O. Westmark	5.00
"	2	R. L. Ettinger..	5.00
"	2	Geo. N. Riley...	5.00
"	2	John O'Brien...	5.00
"	3	F. J. Harrison..	5.00
"	3	Geo. Thompson.	5.00
		Carried forward...	$2,785.00

		Brought forward...	$2,785.00
June	3	M. B. Parker...	5.00
"	8	John Player....	5.00
"	8	John Howard ..	5.00
"	8	P. H. Brangs...	5.00
"	8	Daniel A. Smith	5.00
"	8	L. H. Bryan....	10.00
"	8	W. H. Young...	10.00
"	8	A. B. Withers..	5.00
"	8	Addison Gardner	5.00
"	11	F. L. Bates.....	5.00
"	11	J. G. Clifford...	5.00
"	11	Wm. Kelley.....	5.00
"	11	Frank Robinson	5.00
"	11	Robt. Tawse ...	5.00
"	11	J. A. Graham...	5.00
"	11	Rufus Hill	10.00
"	12	John Whetstone	5.00
"	12	Wm. Smith....	5.00
"	12	D. D. Briggs...	5.00
"	12	Patrick Ryan...	5.00
"	15	F. H. Neward..	10.00
"	15	Edw. Elden....	10.00
"	15	Chas. Graham, Jr.	10.00
			$2,930.00

THE PRESIDENT: Gentlemen, what is your pleasure in regard to the report of the Secretary?

MR. C. A. SELEY: I move that it be received and referred to the Auditing Committee.

Motion seconded and carried.

THE PRESIDENT: The next business is the report of the Treasurer.

The Secretary read the report of the Treasurer, as follows:

To the President and Members of the American Railway Master Mechanics' Association:

Balance on hand June, 1902	$2,700 89
Received from interest to date	56 16
Received from Secretary	128 51
	$2,885 56
Paid to Secretary	800 00
	$2,085 56
Jerome Wheelock Fund	1,000 00
	$3,085 56

ANGUS SINCLAIR, *Treasurer.*

THE PRESIDENT: Unless there is some objection, this report will also be referred to the Auditing Committee. There being no objections, it is so ordered. The next business is the announcement of the annual dues.

THE SECRETARY: At the meeting of the Executive Committee, held last evening, it was decided to recommend that the annual dues for the coming year should be $5 per vote, the same as heretofore.

THE PRESIDENT: If the recommendation of the committee is the sense of the meeting, it is necessary some vote be taken upon it, and a motion will be in order.

MR. H. F. BALL: I move that the recommendation of the Executive Committee, that the dues be $5 per year, be accepted and approved.

Motion seconded and carried.

THE SECRETARY: During the last three or four years it has been customary for the American Railway Master Mechanics' Association to extend an invitation to a representative of the Traveling Engineers' Association to be present and listen to the discussions at our meetings, and to take part in them, if the representative so desired. Following that custom we have with us this morning Mr. W. G. Wallace, traveling engineer of the Chicago and North-Western Railroad, at Clinton, Iowa, who comes as the representative of the Traveling Engineers' Associa-

tion. I would suggest that the courtesies of the floor be extended to Mr. Wallace to take part in our discussions, if he wishes.

THE PRESIDENT: You have heard the remarks of the Secretary, and unless there is some objection, this courtesy will be extended to Mr. Wallace. (No objection.) Mr. Wallace, the courtesy of the floor is extended to you as the representative of the Traveling Engineers' Association.

MR. W. G. WALLACE: I thank you, Mr. President and gentlemen.

THE SECRETARY: During the year applications have been received by your Executive Committee from Mr. T. W. Place, a member since 1874, and Mr. R. W. Bushnell, a member since 1870, that they be placed on the honorary membership list. As these gentlemen have ceased to be engaged in active railway pursuits the Executive Committee recommends that their names be added to the list of honorary members. Under the Constitution this can be voted on at any regular meeting; it does not have to lie over for a year.

MR. P. H. PECK: I move that Mr. T. W. Place and Mr. R. W. Bushnell be placed on the honorary list of membership.

Motion seconded and carried.

THE SECRETARY: I have the following proposal:

To the President and Members:

We propose for associate member Mr. George Hodgins, Associate Editor, *Locomotive Engineering.*

PETER H. PECK,
T. A. LAWES.

Under the Constitution this proposition will have to lie over till the next meeting of the Association before it can be acted upon.

THE SECRETARY: At the convention last year the names of Mr. F. A. Casey and Joseph W. Taylor were proposed for associate membership. The requirements of the Constitution having been complied with the action of the Association on these proposals is now in order.

MR. C. A. SELEY: I move the election of Mr. Taylor and Mr. Casey to associate membership.

Motion seconded and carried.

THE SECRETARY: The next business on my desk is a report of the Executive Committee.

To the Members of the American Railway Master Mechanics' Association:

At the convention of 1902, among the subjects referred to your Executive Committee to consider was one —

"That the usefulness of the Association could be materially increased if the membership were placed on a representative basis on lines similar to the Master Car Builders' Association."

President Waitt, in his annual address, suggested, as a line of future usefulness, the Association might profitably inaugurate tests and experiments affecting locomotive performance, such as the possibility of obtaining "reserve power" which is so greatly needed; experiments on the various lengths of boiler tubes; the relative value of the various kinds of heating surfaces; the possibilities of ribbed or corrugated boiler tubes of the Serve or Whitney types, etc., to be carried on by trained experts and assisted financially from the funds of the Association.

The committee to which was referred for consideration the various recommendations contained in the President's address, favored the suggestion, and made the above recommendation, which is the subject of this report.

As an evidence that it is the desire of the Association, it might be cited that in this year's program there is a committee now investigating the question of locomotive front ends, in conjunction with tests now being conducted at Purdue University, Lafayette, Indiana, by the *American Engineer and Railroad Journal;* also that a committee was selected to outline tests and experiments affecting locomotive performance, to be carried on by experts under the direction of committees of the Association.

The cost of conducting these tests as outlined by the above committee will greatly exceed the present financial resources of the Association, and when continued from year to year, or additional investigations authorized, will vary.

It has been suggested as a means of increasing the revenues of the Association to meet this additional expense, that a representative membership be created, based on the number of engines in actual operation, including engines in shops for repairs.

The constitution provides that it may be amended at any regular meeting by a two-thirds vote of the members present, provided that written notice of the proposed amendment has been given at a previous meeting at least six months before.

In accordance therewith, your committee would propose the following amendments:

Article 3, Section 1, an addition:

One representative member may be appointed by any railroad company to represent its interests in the Association; such appointment shall be in writing and shall emanate from the President, General Manager or

General Superintendent. Such member shall have all the privileges of an active member, including one vote on all questions, and in addition thereto shall, on all measures pertaining to the determination of what tests shall be conducted by the Association or the expenditure of money for conducting same, have one additional vote for each full one hundred engines which are in actual operation or in process of purchase by the road or system which he represents. Such membership shall continue until notice is given the Association of his withdrawal or the appointment of his successor.

Article 3, Section 3, an addition:

A representative member shall pay, in addition to his personal dues as above, an amount for each additional vote to which he is entitled, as shall be determined each year by the Executive Committee, prorated upon the cost of conducting such tests as may be determined upon at each convention, provided that no such assessment shall exceed $5 per vote per year.

The above is simply a notice of amendment and, in accordance with the constitution, should lie on the table until our next annual convention.

THE SECRETARY: Mr. President, that is all the new business I have.

THE PRESIDENT: Under the head of new business, I will ask if Mr. Smith, or Mr. Casanave, of the Pennsylvania Railroad, is present, and whether either of them is ready to make an announcement? In the absence of Mr. Smith and Mr. Casanave, I would ask if any member of the Association has anything to offer under the head of new business?

MR. C. E. FULLER: The Interstate Commerce Commission last March modified the Safety Appliance Law governing the application of grab irons to tenders and locomotives. This law goes into effect September 1. As there is a wide difference in the styles of tenders and tender frames used on the different roads, we would like to obtain the views of the Association as to the proper location for grab irons or hand holds; also their views relative to the proper location and style of grab irons or hand holds on the pilot beam. Most roads have a hand hold on the rear of the tender; some tenders have them on the side and some on the corner. Whether or not this hand hold will be acceptable under the law is a question, and it is with this object in view that we raise this question so that we can obtain the benefit of the views of this Association, and hope that the members will discuss this subject freely. The road with which I am connected has a handle on the side of the tender at the rear, near the corner. On

our extremely wide tenders the hand hold is placed on the corner. This is necessary, owing to clearance, and we are of the opinion that this covers the requirements of the law. We would like the views of the Association on this point. As you are aware, some of the tenders are built with the cistern proper coming flush with the rear of the tender frame, and in this case there would be no difficulty in applying a grab iron to the rear of the tender at the same height as a box car, but a large number of tenders have the cistern forward from the rear of the tender frame twelve or eighteen inches, and a tool-box applied on the frame back of the tender. In this case it would be difficult to apply a grab iron on the rear of the tender. We are of the opinion that a grab iron applied to the tender frame practically the same as on flat cars would answer the purpose. We would like to have the views of the Association on this point as to whether the grab iron applied to the end sill of the tender frame same as a flat car will be acceptable.

THE PRESIDENT: This is an important matter, and I think one which is not generally understood, that the law governing the application of safety appliances includes the tender and the locomotive; and if there is no objection I will appoint a committee to look into this matter. I would appoint as such committee Mr. Thomas Purves, Mr. C. E. Fuller and Mr. P. H. Minshull.

MR. H. F. BALL: Is it understood that this committee will report before the Proceedings are printed? It seems to me this report should be in before the convention adjourns, to be of any value.

THE PRESIDENT: I will say for the benefit of the committee that Mr. Fuller has some prints with him, I understand, showing how the Erie railroad applies grab irons or hand holds and it might be of service to have these prints before the committee in considering the matter; and if any other members have with them at the convention, drawings illustrating their practice in this respect, showing the location of the grab irons or hand holds, we would be glad to have them meet the committee so that the report can be presented to the convention before we adjourn. The time is very brief between now and the first of September, when the new law goes into effect.

MR. P. H. PECK: Mr. George Groobey, one of the inspectors of the Interstate Commerce Commission, is here from Washington, and he can probably give the committee all the information it desires on the subject. He is not in the room, but is at the hotel. I should be glad to introduce him to Mr. Fuller.

THE PRESIDENT: The next business is the appointment of a Committee on Correspondence and Resolutions. The committee last year consisted of Messrs. J. H. McConnell, F. M. Whyte and L. R. Pomeroy. As the committee performed its duties so well last year, it will be reappointed this year.

THE SECRETARY: During the year there were eleven deaths among the members and the President has named the following gentlemen as a Committee on Obituaries. The first is the name of the deceased member, and the second the name of the committee:

John A. Quinn........................	J. F. Walsh.
C. B. Hogsett........................	
W. C. Dallas........................	J. O. Pattee.
A. Hendee........................	E. M. Herr.
Jacob Losey........................	H. Swoyer.
W. L. Holman........................	W. C. Arp.
Edward Grafstrom........................	G. R. Henderson.
E. F. Moore........................	F. W. Lane.
William Swanston........................	S. W. Miller.
George H. Prescott........................	John Ellis.
S. A. Hodgman........................	H. D. Gordon.

THE SECRETARY: The Executive Committee, in considering the matter, did not know any one who knew Mr. Hogsett, and suggested that the fact be announced and inquiry made whether any of the members knew him. The last record we have of him he was located at Morenci, Arizona.

THE PRESIDENT: The Treasurer suggests that Mr. Hancock probably knew Mr. Hogsett. Mr. Hancock, were you acquainted with Mr. Hogsett?

MR. HANCOCK: No; I did not know him.

THE SECRETARY: We will try to find some of our members in the Southwest, or in Mexico, who knew Mr. Hogsett, and if we find such a member will ask him to prepare an obituary notice of Mr. Hogsett.

THE PRESIDENT: The Secretary has some communications from Mr. D. R. Francis, President of the Louisiana Purchase Exposition, the Business Men's League, of St. Louis, and Mr. J. L. Hornsby, President of the Council, of St. Louis, inviting the Association to meet in St. Louis in 1904.

The Secretary read the letters, and, there being no objections, they were referred to the Executive Committee for consideration when deciding (in connection with the Executive Committee of the Master Car Builders' Association) on the place of next convention.

THE PRESIDENT: The next business is the election of an Auditing Committee. Nominations are in order.

The Secretary read the by-law relating to the election of the Auditing Committee.

The following nominations were made:

Mr. O. H. Reynolds nominated Mr. L. R. Pomeroy.

Prof. H. Wade Hibbard nominated Mr. H. D. Taylor.

Mr. T. A. Lawes nominated Mr. C. E. Fuller.

Mr. H. F. Ball moved that the nominations be closed and the Secretary authorized to cast the ballot of the members for the gentlemen nominated. Motion seconded and carried.

THE SECRETARY: I cast the ballot for the three members named; and I will say that the books of the Secretary and the Treasurer are on the desk, ready for inspection at any time.

THE PRESIDENT: The gentlemen nominated have been duly elected as the Auditing Committee.

The next business in order is the report of the Committee on Ton-mile Statistics. Mr. C. H. Quereau is chairman of the committee.

MR. QUEREAU: Mr. President, and gentlemen of the Association: The report is not long, because the special duty assigned to the committee for this last year was to recommend a credit of ton-mileage for switch locomotives. Two of the members of the committee were impressed with the fact that the proper credit would be one which was in proportion to the tonnage entering the station at which switch engines were at work; but we were unable to propose any satisfactory method of arriving at such a proper credit, and, therefore, nothing of the kind is presented.

Most of the report is given over to the statement of the result of a test made for the *Railroad Gazette,* by a member of the committee, Mr. George L. Fowler, for determining what was the average mileage of engines in switching service. If you have read the article, or the committee's report, I have no doubt most of you will be considerably surprised to see that the present arbitrary credit of six miles an hour is almost twice too high. These tests were carefully made and carefully checked, and the revolution counter was examined at stated intervals; and I hope Mr. Fowler will have a little more to say as to the methods used and the machinery employed in getting these statistics.

I would say, in a general way, that the first records he obtained showed such a low mileage that he decided they must be wrong — something certainly must be wrong with the apparatus or with the method of checking it up — but subsequent events have proved that his first records were probably correct. I will read a few sentences from the report; first, the paragraph, beginning at the bottom of page 2.

REPORT OF COMMITTEE ON TON-MILE STATISTICS.

To the Members of the American Railway Master Mechanics' Association:

The committee was continued with the special purpose of making recommendations as to the proper ton-mile credit for switch engines. In this connection the results obtained by Mr. Geo. L. Fowler, through an investigation made for the *Railroad Gazette* and published in the issue of May 8, 1903, are exceedingly interesting. The following is the article complete:

"It has been the accepted practice, since the convention of the Master Mechanics' Association in Boston in 1872, to credit a switching locomotive with six miles an hour for the time that it is in service. Other arbitrary mileages have been proposed from time to time, but all have been, more or less, based upon the averaging of a number of guesses.

"It is with a view of securing some definite information upon this subject that Mr. George L. Fowler, with the coöperation of a number of railroad officials, has been conducting a series of investigations on engines in service. The gentlemen through whom arrangements were made and to whom acknowledgements are due for the courtesies extended are Messrs. W. F. Potter, General Superintendent Long Island Railroad; A. M. Waitt, late Superintendent Motive Power of the New York Central; F. D. Casanave, General Superintendent Motive Power of the Baltimore & Ohio; W. S. Morris, Superintendent Motive Power of the Erie, and

G. W. West, Superintendent Motive Power of the New York, Ontario & Western.

"A revolution counter was attached to the crosshead of the engine so that each revolution, either forward or backward, would be recorded. The counter was kindly furnished by the Crosby Steam Gage & Valve Co. A short connection was pivoted on a stud screwed into the crosshead and led back to a swinging arm hung on a bracket bolted to the running board. From this arm another connection was carried forward to the swinging arm of the counter.

"Readings were taken every day, but engines that were in service twenty-four hours a day were frequently read every morning and evening. The time was kept in the office of the Engine Dispatcher, so that with the time, the number of revolutions and diameter of the driving wheels the average mileage per hour was computed. Some objections were raised to this method of ascertaining the mileage, on the ground that the slipping of the wheels was counted. All the superintendents of motive power, to whom this matter was referred, believed that the engines should receive credit for the slippage which taxes their endurance to the greatest extent. Another objection was that the mileage obtained in different yards and in different services would vary to such an extent that any generalization would be impossible. It was, of course, out of the question to answer this objection in advance, because of the total lack of information on the subject. Observation has shown, however, that the average variation is not as great as that of the same engine in the same service from day to day in a freight yard, although the average daily mileage of an engine in passenger service is remarkably uniform on account of the regular service demanded.

"The chief point which has been brought out is that the arbitrary allowance of six miles an hour is altogether too high. The length of time during which the instrument was kept on the engine was never less than two weeks, and in one case it was eleven and one-half weeks. It was put upon nine different engines, five of which were used in freight and four in passenger switching. It was found that in every case, in comparing engines upon the same road, the mileage of the passenger was greater than that of the freight engine. All engines were the six-wheel or O-6-O type with a tender, there being small difference in the general dimensions. The following tables give the dimensions of the engines and the mileage made by each during the test:

MILEAGE OF FREIGHT SWITCH ENGINES.

Road.	Place of Trial.	Total Mileage.	Total Hours in Service.	Total Hours in Service, less time at Coaling Station.	Average Mileage for total Hours in Service.	Average Mileage for total Hours in Service, less time at Coaling Stat'n.
N. Y. O. & W.	Norwich .... N. Y.	2,938.5	1,198.5	....	2.50	....
Long Island	Jamaica .... "	831.94	336.5	322.5	2.47	2.58
N. Y. C. & H. R.	West Albany ...... "	667.16	312.0	298.0	2.14	2.24
B. & O.	St. George .... "	638.66	249.5	223.5	2.52	2.86
Erie	Jersey City .... "	660.30	352.0	326.0	1.94	2.03
Average	....	....	....	....	2.31	2.43

MILEAGE OF PASSENGER SWITCH ENGINES.

Long Island	Long Island City . N. Y.	702.96	229.25	214.75	3.07	3.27
N. Y. C. & H. R.	Mott Haven .... "	468.51	193.00	178.00	2.43	2.63
B. & O	Baltimore .... Md.	839.27	320.50	293.50	2.62	2.86
Erie	Jersey City .... N. J.	549.02	184 50	172.50	2.98	3.18
Average	....	....	....	....	2.78	2.99

"Mr. E. T. White, Superintendent of Motive Power on the Baltimore & Ohio, made a number of similar trials on that road a few years ago. Mr. White's results are, however, somewhat higher than those obtained in this work and are as follows:

Location.	Miles made in 24 hours.	Miles made per hour.
Baltimore	88	3.66
Baltimore	72.5	3.02
Philadelphia	76.33	3.20
Philadelphia	90.80	3.75
Brunswick	83.82	3.49
Brunswick	83.42	3 47

"The class of service of these engines is not known except that the one in Philadelphia, making an average of 3.75 miles an hour, was at work where there was a long haul, a condition that is particularly favorable to a high average mileage. Each test lasted from three to five days. The average of these six engines is 3.43 miles per hour, or a trifle more than the highest average made by any one of the engines in the recent trials. This investigation on the Baltimore & Ohio was made in February, 1899, and it has been suggested that the discrepancy between the trials made at that time and those just completed is due to two causes: The present congested condition of the yards and the increase in the number of high capacity cars, whereby the engines are more heavily loaded, and, therefore, move very slowly.

"Careful observation has led to the conclusion that under the ordinary

conditions of strictly yard work, it is impossible for an engine to maintain an average of even four miles an hour for several hours at a time. Under certain very favorable conditions during the past six months engines have made five miles an hour for fifteen minutes, but never even four miles for a half hour at a time. For strictly yard work, four miles an hour for passenger switchers, and three and one-half miles for freight switchers would undoubtedly be a liberal allowance. One who has not paid particular attention to this matter will be surprised at the comparative slowness of all switching engine movements. The time consumed in standing still cuts down the average speeds. Whether it is possible to improve the record can not be either affirmed or denied from the data at present available, but certainly it does appear to be a matter that is worthy of further investigation."

In view of the care with which these records were taken, the length of time covered in each case and the fairly close agreement of the several records, it seems fair to conclude that the results agree reasonably with the facts. On this basis, three miles an hour for switch engines doing freight work and three and one-half miles an hour for passenger switch engines, appear to be a fair credit. If we had equally reliable data as to the average tonnage handled, a comparatively accurate credit of ton-mileage could be proposed, but inasmuch as we know of no such records and the credit would be an arbitrary one, we have thought best to make no recommendation.

The question of Railway Statistics, including the matter of Motive Power Statistics, is being considered by a committee of the American Railway Association. Two of the members of their committee are motive power officials, and one of these is a member of the Master Mechanics' Association. In view of these facts we would recommend that no further action be taken by this association and that the committee be discharged.

C. H. QUEREAU, Chairman,
G. R. HENDERSON,
GEORGE L. FOWLER,
Committee.

W. ALBANY, N. Y., June 5, 1903.

MR. QUEREAU: I have no doubt most of us will be astounded at these results, but I do not see how we can question them.

In justice to Mr. Fowler, a member of this committee, and in justice to the Association, I think it only fair to say that he has a minority recommendation to make, as he is decidedly of the opinion that there is work for a committee of this Association in determining a proper credit of ton-mileage for switching locomotives. I would, therefore, suggest to the President that he call upon Mr. Fowler, that he may present his side of the case.

THE PRESIDENT: We will be glad to hear from Mr. Fowler.

MR. GEORGE L. FOWLER: I do not think there is any member of the Association who is more surprised at the results obtained in this switch-engine investigation than I was myself. As Mr. Quereau has already said, after making the investigations on the first road that was tried, I turned down the results and said nothing about them — simply because I did not dare to. I thought that the Association knew so much better than I about what the mileage ought to be, that I had better keep quiet until I knew more about it. But the results, as checked off in the report, show that there is a very even running of engines that are doing strictly switching-engine work. What I mean by that is an engine that is shifting cars, breaking up trains, and making short runs. If an engine has a long run, of a mile or more, the mileage will run up and exceed anything I obtained. I have prepared a short résumé here of what has been done by the Association in regard to this matter, which perhaps I had better present previous to my minority recommendation for an amendment to the report of the committee.

In crediting switching locomotives with six miles an hour there has apparently been no questioning of the approximate accuracy and fairness of this allowance, at least in public, and so the guess, for it is nothing more, has been allowed to pass unchallenged.

It appears from the reports of this Association that attention was first directed to this matter in a committee report on a Uniform System of Locomotive Reports, submitted to the convention held in Philadelphia in 1870, wherein it was stated that there was "a great variation in mileage assigned to switching engines," and the committee recommended "a uniform rate of ten miles per hour, while said engines are on duty."

In the discussion of the report objection was raised to the allowance of ten miles an hour as giving an abnormally high mileage for the amount of coal burned. The recommendation was not adopted, but the matter was afterwards referred to another committee on Computing Mileage of Engines Doing Switching Service, that reported at the Boston convention in 1872. This committee issued a circular to which they "received replies from thirty-two superintendents of motive power and master mechanics, representing nearly all the principal lines of railway in the United States and one in Canada, and from these we find that three of these lines compute mileage for engines doing switching service exclusively, at the rate of ten miles per hour for the time that the engines are in actual service, three at eight miles per hour; three from six to seven miles per hour; fourteen at five miles per hour, and the remainder at less than five miles per hour."

From the replies elicited and from their "own observations, and experience in keeping up the repairs of engines engaged in switching service exclusively," they recommended "that, for this service, six miles per hour for the time that such engines are in actual use be allowed," the chairman explaining later in the discussion that the committee "did not propose to recommend the engines should be allowed mileage during the noon hour or time when the engine is standing still for some considerable time."

This recommendation was adopted and has since been almost universally used, except that it is common practice to credit the engine for all of the time that it is in service, making no allowance for noon hour or time spent at the coaling station. In other words, crediting an engine with 144 miles for twenty-four hours duty.

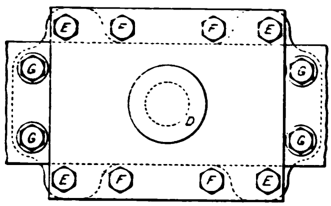
In 1892 a committee on Uniform Locomotive Performance recommended that all engines in switching service be allowed at the rate of eight miles an hour, but it was thought by the convention that there was no justification for such an increase and the recommendation was not adopted.

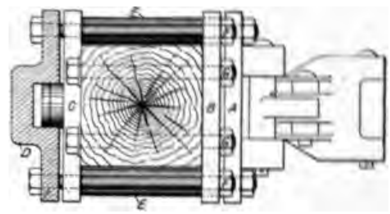
The next proposal to change this credit came from the committee on Ton-mile Basis for Motive Power Statistics reporting at Saratoga in 1900. This committee held that as "engines in switching service are credited with an arbitrary number of miles per hour, there is no reason why they should not be credited with an arbitrary ton-mileage instead." Nothing, however, has yet been done on this point.

The mileage credit for switching service that has been in use for the past thirty years, is, therefore, based upon the averaging of a number of guesses.

The comparatively small amount of work that I have had to do in the investigation of switching-engine mileage has made me quite positive as to the possibilities of engines doing a strictly yard work, but has left me uncertain as to what those switching engines may be able to do that are engaged in transfer work or which have especially long hauls such as the passenger switchers used between the Grand Central Depot and Mott Haven in New York, where there is a straight run of about five miles.

MR. FOWLER: [Continuing verbal statement.] Having done that work, I know, of course, that the bare knowing of the mileage of the engines did not give any idea as to what the amount of work was that the engines were actually doing. Of course, we all believe that the heavy engines that are being used to-day are doing very much more work than the lighter ones that were in service a number of years ago; but, in order that I might have something to present to the Association on that matter. I have designed in rough outline a dynamometer, of which engravings have been passed around, for measuring the work that the engine was doing. This engraving simply shows the attachment on the





DOUBLE ACTING DYNAMOMETER

FOR

SWITCHING ENGINE SERVICE

SCALE

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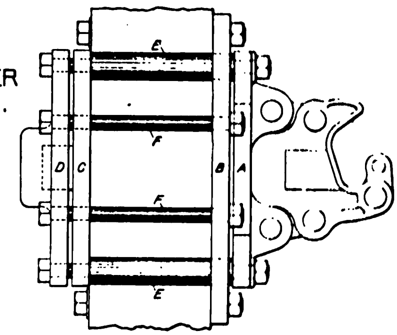


buffer. I will make a brief explanation of the way in which it works. The bumper timber is shown in the upper right-hand corner cross-hatched as wood, against which there is a plate B bolted securely to it by bolts G. This plate is immovable and is attached to the buffer, but should be supplied with lugs, not shown in the engraving, and possibly with a pocket for supporting the drawbar itself, that is, the coupler. The coupler that is shown is one of the Gould type that happened to be at hand when the drawings were made. This is attached rigidly to the plate A. Passing through the plate A is the bolt E, with a heavy shoulder against the plate A, and also another shoulder against the plate C, so that if A is pushed back by buffing, the plate C is carried back with it. The hydraulic cylinder is shown at D, and that is bolted by the bolts F to the plate B, so that it can not move any further from it than the bolts are adjusted for, but is free to move toward it. If, then, there is a buffing stress applied to the coupler, the plate C is pushed back and the plunger creates a pressure in the space in the cylinder. If, on the other hand, there is a pulling stress, the plate A is moved away and pulls against the cylinder D by means of the bolts E, but the plate C can not follow it and

comes up against the buffer beam, and that also puts a pressure in the cylinder, so whether there is a buffing stress or pulling stress, we still have the compression of the liquid in the cylinder.

Some objection might possibly be made to the use of a hydraulic cylinder for measuring these pressures, but a number of years ago I had some experience in the matter and found that for very small cylinders there was an excessive frictional resistance due to the packing, but I afterward found that the frictional resistance of cup packing and U packing for hydraulic work had been carefully worked out and a formula deduced from it which is correct and which I have checked off on cylinders measuring from three-quarters of an inch to ten inches in diameter, and find the variation a negligible quantity for any such work as we have in hand. This, of course, is a small part of the apparatus. For the registering part of the apparatus I went to the Bristol Company, which has probably had more experience with automatic recording gauges than any other concern in the country, and told them exactly what I wanted to accomplish, the terrific stresses, the sudden jars that would have to be met, and how little attention the apparatus would receive from the attendant, and they said they could build an apparatus that would do the work and be very simple. If further experiments were to be carried out in this matter, I would suggest that a dynamometer such as I have shown, with perhaps a larger cylinder, so as to reduce cylinder pressure, be put at each end of the locomotive and a recording apparatus connected with each one, so that you would have not only the mileage of the engine, but also the amount of work which it does for every movement that it makes. That would make an actual mileage record which would probably be less than the mileage record that I have given here.

My method of doing this work was simply to attach the revolution counter to the cross-head of the engine, so that, no matter in which direction it was moving, for each stroke of the cross-head I obtained a count, one; and right here I wish to say that when I went to the Crosby Steam Gage and Valve Company, and told them what I wanted to do and that the results of my work would probably be presented to this Association they very kindly, for the benefit of the Master Mechanics' Association, gave me a revolution counter which was put in service and which I used

throughout. The revolution counter is now pretty nearly a wreck, although in good, serviceable condition. You can imagine the state of the instrument after being exposed for eight or ten months to such service; and the action of the Crosby Steam Gage and Valve Company certainly deserves the thanks of the Association for their courtesy to me in this respect.

When the report of the committee was presented to me for signature, I demurred, but agreed to sign the report. I told my fellow committeemen that I thought there was still work enough for the committee to do, and one point on which I differed from the other members of the committee was that the committee ought not to ask to be discharged, but rather ask to be continued; and I recommend that in place of the last paragraph on page four of the report of the committee as submitted, this substitution be put in its place:

"The question of railway statistics, including the matter of motive power statistics, is being considered by a committee of the American Railway Association. Two of the members of that committee are motive power officials and one of these is a member of the Master Mechanics' Association. In view of these facts it is evident that no final action should be taken by this Association without a conference with this committee of the American Railway Association. In a previous report your committee urged the advisability of using a ton-mileage basis for switching-engine work and it is not inclined to recede from this positon. It frankly acknowledges, however, that it is not yet in possession of sufficient data to make a positive recommendation on this subject. It is evident from what has preceded in this report that the mileage of switching engines has been a matter of pure guesswork for many years. The weight of switching engines, like that of other classes of motive power, has been more than doubled since the six mile an hour basis was adopted for these statistics. There are some indications which go to show that these heavier engines are making less mileage than the lighter ones, at the same time it is probable that their ton-mileage is very much greater.

"Your committee recognizes the difficulty of an investigation into the ton-mileage of switching engines. The service is so severe that it is hardly probable that the owners of a dynamometer car would care to subject it to such work for the length of time necessary to obtain the data of any value. In order to overcome this difficulty and at the same time secure this information without incurring an excessive expense one member of your committee has been engaged in an attempt to design a dynamometer which would be automatic in its action and require no attention except the daily renewal of the record sheet. If such a dynamometer be built and applied to switching engines it is believed that information

of such a character that would warrant the establishment of a ton-mile basis for switching engines could be obtained.

"Another point referred to this committee is that of the proper credits for local freight-work engines. The data obtained in connection with the switching engines has rendered your committee cautious in regard to making any recommendations in the matter of these two services. It is therefore recommended that an investigation similar to that made in connection with switching service be made on both work and local freight engines. With such data at hand, coupled with the known weights and number of cars hauled, the determination of ton-mileage for these two services would be a comparatively easy matter.

"In view of the information obtained during the past year the committee does not feel warranted in making any further recommendations as to locomotive statistics than those given above relating to switching-engine mileage. It would, however, recommend that it be authorized, during the coming year, to make an investigation into the mileage allowance to be given to local freight and work engines and also to enter into an investigation of the ton-mileage of switching engines, and would ask to be continued for that purpose.

THE PRESIDENT: Mr. Quereau, do you care to say anything further?

MR. QUEREAU: I think possibly I had better wait until some one else has spoken on the subject.

PROFESSOR HIBBARD: One small suggestion might be made at this point. Possibly the Association may feel disturbed with regard to the expense that may be involved in carrying out the last suggestion made by Mr. Fowler. The Carnegie Institute in Washington has an immense fund to be put into operation for making investigations of various kinds. I know that the institution with which I am connected has this past year been the recipient of an appropriation of something like $2,000 from the Carnegie Institute for carrying on some marine experiments, and I would suggest that possibly that same fund might be available, upon application from this Association, for carrying out the investigation suggested.

MR. ANGUS SINCLAIR: I think there is a tendency in this report to put too much weight on the actual work that an engine is doing, pulling or pushing cars. When an engine is out in a switching yard, a great part of the work done, at least so far as expense to the department is concerned, is when the engine is not pulling or pushing cars. An engine may pull for three or four

minutes at its maximum, and your indicator would give that as the whole work done, while in the next three or four minutes the engine is using as much fuel as when it was pulling the cars — the consequence is, in that fluctuating work, an engine is not only consuming a great deal of fuel and oil, but is wearing itself out even more rapidly than it would do under the ordinary circumstances of regular work. The fluctuating work is harder on the heating surfaces than steady work would be, which would show much greater mileage.

I have heard this subject repeatedly discussed in the Master Mechanics' Association, and the idea followed was to agree on a fair mileage, so that the Mechanical Department would be given credit for work done by the engines, in relation to the expense incurred. If you get down to the actual mileage you will not have anything like the actual work done by the engine. Consequently, I think it is much more equitable and nearer justice to the Mechanical Department to estimate a fair day's mileage by the hours the engine is at work. I always thought the proposal that the engine should not have any credit for the meal hours was absurd, because very often the engine was burning as much coal in the meal hour as it was in light work when it was switching. I think it would be better for the Association to gather the data of experience, and on that establish a mileage, rather than by the gauges which have been used to ascertain the actual mileage. I think the Association should take a wide view of the general work done by the engine.

The President: It seems to me that any one at all familiar with the present method of switching, and observing the way in which our modern engines give a train of fifteen or twenty cars a little shunt, and stand still while the cars go back and destroy $200 worth of freight equipment every switch they make, will agree that it is not fair to credit the department with the actual mileage. I probably can illustrate this question no better than by giving an incident which occurred on Staten Island during the Civil War. There was a man in New York who formed a regiment of toughs and called them Billy Wilson's Zouaves. They encamped on Staten Island, and after being there a short time an old Methodist minister heard of their reputation, and he collected a small sum of money and went to the encampment and inquired

for Mr. Wilson. That personage was pointed out to him and the minister said, "Our church has heard a good deal about your soldiers here, and we have taken up a little collection for the soldiers. I had the money when I came into camp, but I haven't got it now." Billy Wilson said, "You had it when you came inside?" "Yes," said the minister, "I put my hand in my pocket after passing the guard and the money was there." Billy Wilson said, "Your congregation shall have credit for it; the regiment's got it." That is the condition of the switching service. The companies get the service, only in a different way. The engines formerly followed the cars in switching, but now they give them a run; they make less mileage, but they do the work.

Mr. P. H. Peck: It will surprise our members to discover how expensive per mile switching engines are. If the committee allows three miles an hour for switching engines, they would make not more than twelve thousand miles a year; we would turn our tires every six or seven thousand miles. The flues would run eighteen thousand miles, and would have to wear double that to get anywhere near the comparative cost of the road engine. On such an engine a 3½-inch tire would wear out in about three years. We would get no mileage at all on that basis. I do not think you can compare the expenses on the two classes of engines, for the reason that the locomotive repairs would be about 12 cents a mile, coal about 15 cents, and tire wear about 1 cent a mile.

Mr. A. L. Humphrey: If we could arrive at an actual ton-mile basis for switch engines, the same as for road engines, there is no doubt it would be very beneficial in making up our statistics. In my opinion that would be impracticable. So far as mileage for switch engines is concerned, I personally think that the six miles is entirely too low for our modern locomotives, weighing 140,000 to 150,000 pounds on the drivers, that will haul double the tonnage of locomotives of 60,000 and 70,000 pounds on the drivers. To figure them on the same basis would be inconsistent. This committee says that "For strictly yard work, four miles an hour for passenger switchers and 3½ miles for freight switchers would undoubtedly be a liberal allowance." I believe any one who has watched the expense of switching locomotives of heavy type, will agree with me that the switching locomotives prove to be

the most expensive locomotives we have to maintain of a heavy type. For instance, a locomotive with a 20 by 26 inch cylinder, as Mr. Peck suggested, would run 30 to 35 cents a mile in switching service, such as we have. If we should arrive at a mileage of not less than six miles per hour for all locomotives, it would be a very fair compromise; and for the heavy locomotives, if you were going to make a distinction, ten miles an hour would not be inconsistent. I would dislike to see any change made in the six miles an hour.

MR. J. W. HILL: My experience has covered some sixteen years with that class of locomotive almost exclusively, the same as Mr. Peck referred to. I am thoroughly convinced that the mileage is too low at present on the heavy locomotives. The cost is running up on them and the mileage we are getting out of flues and tires is running down, and if any change is made, the mileage should be raised.

MR. QUEREAU: Not to close the debate, but to present what seems to me to be a more reasonable view of the question than most of the speakers so far have advocated, is the object of my rising. With all due deference to the remarks of the gentlemen who say that a mileage of six miles is none too large, I must venture to disagree, and without any personal reference in any direction, I will say that I am reminded of the story of the ostrich which thinks it hides itself when it hides its head. If any good has come out of ton-mile statistics in motive power departments, it has been in getting exact facts. It is not so much a question whether our cost goes up, or whether it goes down, if we know what the cost actually is. The time was when a passenger locomotive was assumed to be more economical in the consumption of fuel than freight engines. Why? Because it made more miles to the ton of coal. The use of the ton-mileage system shows the work done by the locomotive, and has convinced every one who has followed the facts that a passenger locomotive is more expensive in fuel than the freight locomotive. Why? Because the ton-mile basis gives exact facts — I do not mean mathematically exact, but a fair basis on which to judge efficiencies. It seems to me, instead of hiding our heads in the sand like an ostrich and increasing a credit which is in itself arbitrary, and

not representative of the work done, we should attempt to arrive at the facts; and if it costs ten times as much to maintain a switch as a freight or passenger engine, we should know the fact, and not make the cost of our repairs on switch engines average with the cost of repairs on freight engines unless it represents the fact. It is altogether a false idea. I hope you will excuse me for being so emphatic. I have followed the matter of ton-mile for some time, and I believe the majority of our members will agree with me that it has done much to place the motive power department on a proper basis and to put arguments in our hands to convince our superior officers that it costs more to run passenger engines than freight engines.

I know a road which has mountain mileage and prairie mileage on which, on the old basis of cost per mile, it was shown to cost no more to operate on the mountain division than on the prairie division. Why? Because they made so many miles per ton of coal. When they got statistics on the ton-mile basis, it was discovered that it cost several times more for fuel on the mountain division. Why this result? Because the basis gave facts and not guesswork; because the basis showed the work which was done. All who have had anything to do with the fuel records of engines will know that on the old basis of so many miles per ton of coal, we were always in a wrangle. The engineers said our figures did not amount to a hill of beans. When we got facts and could convince the engineer our statistics on the ton-mile basis were a fair thing to him, we were able to make savings we could not otherwise do, because we had the facts on which to base our arguments. The same thing applies to a switching locomotive and it would be a mistake, in my judgment, to undertake to make a credit, or increase the credit, for the sake of making on paper the cost of repairs and fuel of switch engines even with those of freight and passenger engines, when we know it is not so. We have been convinced on this floor that it is costing us more to maintain switch engines. Why? Because we have a basis by which we can show it is costing more, and must cost more. A ton-mile basis should be used. The committee was simply in a quandary as how to get at the exact facts in the case.

There is one fact which has been overlooked in this discussion, and that is that the committee last year recommended, and

this Association adopted, a resolution to the effect that the credit of ton-mileage for switch engines should be in proportion to their tractive power. That will take care of the different sizes of switch engines and the different credits which go to them. We can not then say that our big 19 by 24 or 26 engines do not receive a credit proportionate to that received by the 16 by 20. That is provided for in the resolution which has already been passed by this Association.

I would like very much to see some satisfactory method of arriving at a credit of ton-miles for switching locomotives, but at present I do not see any practicable way of getting at it. Inasmuch as this subject is being considered by a committee of the American Railway Association, which has not yet reached the matter of switching engines, it seemed to me wise that this committee should be discontinued. I wish to say in that connection, too, that as chairman of the committee — of course, it may be an assumption on my part, that if the committee is continued I would be made the chairman, but making that assumption, if you please, whether warranted by facts or not — I feel I can not give the matter the attention it really deserves and that was one reason that influenced me in making the recommendation I did.

Before leaving the floor I wish to protest as strongly as I can against the argument and theory that we should cover up facts. Nothing would put us in stronger position before our superior officers and give us more confidence in ourselves, nothing will enable us to judge results of changes, any better than to get facts. I think every one will admit, as a general proposition, that to be true; and why not apply it to switching engines? If they cost us 35 cents a mile, or ten times for fuel and repairs what the passenger and freight engines cost, let us face the facts, and when we have the facts we will be in better position to apply a remedy than if we undertake to hide our heads in the sand.

I want to read a note handed me by the Secretary, written by Mr. C. B. Conger, who is not a member of the Association, and without his permission I will venture to read it, as it confirms the results given in our report:

"In 1891 I put a counter on a switch engine in transfer service between sawmills and lumber yards along the river, where the extreme points in the yard were eight miles apart. As the record

showed a little less than four miles per hour I was only laughed at and my records turned down; so I was obliged to keep quiet. Now, I am backed up by this Association."

Mr. P. H. Peck: I agree with Mr. Quereau as to the importance of one thing, and that is getting at the facts: but you can not get at the facts as easily on switching engines as on other classes of engines. We need to get the facts as to wear and cost of repairs. The revolutions of the driver, as shown by the indicator, would only show pulling and work, and not the wear when shut off. The brake power wears the engine as much as when it is using steam. In many yards the brake is used more hours per day than the steam is used through the cylinders, and we can not get the results of wear that we can on road engines.

Mr. David Brown: The matter under discussion is a very important one, and it is a matter concerning which we can not very well deviate from what we are doing. In my opinion, it would be ridiculous to consider anything less than six miles an hour. We can not blame the committee for holding up its point as well as it can. It is appointed to investigate this matter and to make the best case it can, and, of course, does not like to see the matter settled in a different way. At the same time, we must take facts, for instance, the note from Mr. Conger; there is no doubt at the time Mr. Conger refers to there were very small engines in switching service, different from the present switching engine. We have engines weighing 132,000 and 134,000 pounds on three pairs of drivers, which is a pretty good weight. To illustrate the matter, suppose we allowed three miles an hour: that would be sixty-six miles a day and would be 1,980 miles a month. In eight months I have seen the tires wear down so that they had to be turned. Eight months would make a mileage of 15,840 miles, and we know that is ridiculous. Double that, making it six miles an hour, which we are doing, and it is only 31,680 miles. We know tires ought to stand that in eight months; and I think it would be a bad principle for us to reduce it. I think six miles an hour is low.

Mr. F. H. Clark: I am heartily in favor of the ton-mile basis for locomotive records, so far as it can be used to give us any definite information. I agree, however, with the committee that

there is not much they can do in the case of switching service. I can see, of course, that it would be possible to rig up apparatus and apply it to the switch engine and get accurate records of work done, but it would be expensive and I do not believe the information would be worth the expense involved. I think the point made by Mr. Quereau is a very good one, and that is, we should eliminate guesswork as far as possible.

With the idea of eliminating guesswork, the road with which I am connected has come to the conclusion that we should drop the mileage basis altogether so far as switch engines are concerned and use the hourly basis instead. The mileage of switching engines is variable at best. If you fix an arbitrary figure of six or ten miles an hour, no matter what it is, we know it is not correct, except in very few cases. With that idea in mind we have gone back to the hourly basis, and I consider it as good a basis as any.

MR. S. W. MILLER: I can not too strongly endorse Mr. Quereau's position in this matter. It is a fact that our switch engines, in different service, are exceedingly expensive machines. If we do not know what they cost, in comparison with our other engines, there is no way by which we can go to work to reduce the expense. If we put it on the basis of six, eight or ten miles an hour, and say that the expense will be about what the road locomotives cost us, there will be no inducement for anyone connected with the railroad to reduce in any way the expense of operating these expensive machines. As a matter of principle, I do not think we can afford to endorse any guesswork. As far as the road with which I am connected is concerned, we have found that the figures given by the committee in regard to switch-engine mileage are corroborated at almost every point on the system.

MR. GEORGE L. FOWLER: The matter has been brought up of crediting the engines with six miles an hour, because the roads are using heavy engines. I want to say that, unfortunately, it was omitted from the report, but in the article in the *Railroad Gazette,* from which this report was taken, the size of cylinders and weights on the drivers were given. The weights of the

engines ran from 90,000 to 110,000 pounds, the size of cylinders averaged about 19 by 26; so much for the size of the engine.

I will state a little personal experience in regard to the matter. The names are all given in the report so I need not mind mentioning them. My first engine was on Mr. West's road at Norwich, New York. I left the engine in charge of a man in whom I had implicit confidence, and whom I believe did not betray it. He kept the record almost daily for eleven weeks and sent the performance of the engine to me, and, as you see, he gave me 2.5 miles an hour. I turned it down; said he must have been asleep, and I did not do anything with it. I was thoroughly imbued with the idea that six miles an hour was the proper thing. I went over to the Long Island Road, at the Jamaica yard. They were not congested, just running along in the ordinary work, did not have heavy through traffic, or anything of that sort; and they gave me an engine which they thought was doing the best mileage there. That dropped down to 2.47, not quite as good as the engine on Mr. West's road. I began to think then that the first figures might be correct. I went to Long Island City, and there obtained the best mileage of any engine tried, a little over three miles an hour. I went to the New York Central next and told them what I had obtained on the Long Island Road and on the New York, Ontario & Western. They laughed and said they would show me some mileage, and gave me an engine which they said was doing the biggest mileage there; but this engine did not turn out to be as good as any of the other three. Then I went to West Albany and they gave me an engine which was to knock out everything else; and that engine went straight down the line. The more data I obtained, the more positive every one was that the next engine would give a high mileage record and yet the result was that the last engine tried made the lowest mileage of any. If your switch engines only make one mile an hour and it costs $10 a mile for repairs, say so; do not get up and cover your head and say it only costs 20 cents a mile for repairs, because that is what you can repair your freight engines for. It at least behooves the members of this Association to be honest with themselves and with their records, and if an engine makes only one mile an hour, say so, and charge up repairs accordingly and do not make the whole thing absurd and unreliable simply because

a road engine costs less for repairs than a switcher. That is a fact that no one can get around, no matter how much the reports and records may be doctored. At least, get the credit for telling the truth, no matter what the showing may be.

Mr. Humphrey: I agree with the gentleman thoroughly, so far as getting at actual facts is concerned; we may deceive our neighbors, or our enemies, but let us not deceive ourselves. It seems to me the gentlemen who made this report tried to deceive themselves by imagining their heads were covered. They do not take into consideration the number of revolutions that a locomotive in such service makes that is not regarded as mileage. There is no locomotive engineer who can run a locomotive in such service without the locomotive doing a great amount of slipping. That locomotive is constantly in operation, whether it makes one mile an hour or ten miles an hour, and it is the day's mileage that should be recorded in its favor. I do not believe it is possible to arrive at the actual mileage of a locomotive. We have in Chicago locomotives running one hundred miles a day in switching service, doing business between transfers, and that locomotive gets credit for six miles an hour. We have other locomotives of heavy type which do not do six miles an hour, but if you take the revolutions made by the two locomotives, the one that performs the least mileage is the locomotive that performs the greatest number of revolutions. If we get at the basis suggested, we are deceiving ourselves; and we know there are departments on the railroad which want to use the mechanical department, if you please, as a catspaw to reduce the expenses per ton-mile hauled. I am anxious to reduce the expenses per ton-mile hauled, but I do not want to do it to the credit of the other fellow and to the detriment of myself. Let us see if we can get at an actual basis. If we can get at the ton-mileage basis, I am perfectly willing to do it; but we know what the trouble and expense is in getting at the ton-mile basis. We know that complaint has been made of the expense of getting at the ton-mileage basis of revenue freight hauled. If they complain about the cost of arriving at the ton-mile basis of revenue freight hauled, what will be said of the same system applied to the non-revenue switching service? I think the suggestion would certainly be vetoed by those who look after the expense problem and not the actual results obtained. We would

be compelled to fall back on the mileage of three miles per hour, which would increase the cost of locomotives very materially, the ton-mile as well as the locomotive-mile, and I can not see where the representative of the motive power department will be benefited, or the railroad company, in which we are interested. Let us be candid with ourselves and stand by what we know is right.

MR. WILLIAM FORSYTH: There does not seem to be any prospect of arriving at any decision on this question; there is too much difference of opinion. I would move that, as Mr. Quereau has made a very good argument for continuing the committee, the committee be continued and instructed to confer with the committee of the American Railway Association and to make a positive recommendation next year.

MR. QUEREAU: I dislike to disagree with my friend Mr. Humphrey; as we are both from the West; at the same time he has placed me on the defensive. I do not know that you have heard the story concerning circumstantial evidence — as to the relative value of direct and circumstantial evidence. One lawyer contended that direct evidence only should be used to convict a man of an offense. The other lawyer maintained that circumstantial evidence was even stronger than direct evidence, in some cases, and would warrant a conviction, perhaps even more than direct evidence. The latter used a certain illustration: A milkman was delivering milk one morning, and he was asked if he had put water in the milk. He said no. There is the direct evidence. The customer took the cover off the can and out leaped a frog. There is the circumstantial evidence. This illustration was used by the lawyer to show that circumstantial evidence was stronger than direct evidence. The circumstantial evidence in this case is that Mr. Humphrey has not read the report of this committee, or he would have seen that the slipping of the locomotive is taken into account.

MR. HUMPHREY: The locomotives you tested?

MR. QUEREAU: Yes.

MR. HUMPHREY: How about the thousands of locomotives you did not test?

MR. QUEREAU: There is no reason why these locomotives

should not slip in as large a percentage of cases as would the locomotives which were not tested. If the figures are reliable in any respect, they are as reliable in regard to the slipping as anything else, because of the method of taking the record. I do not think any of us will be startled as to the item of cost in compiling these ton-mile statistics for switch engines, provided we can once arrive at a fair basis. Experience has shown that the cost of obtaining ton-mile statistics is no greater than that of obtaining mileage statistics. The statistics are kept by all our roads on the mileage basis. If we can once arrive at a fair basis, for the ton-mile credit, it will occasion no more difficulty than now; if we do reach that basis we will have something with which we can go to our superior officers and say, "This is costing more than you think it is, and we should receive more credit than we now do," and that would be the inevitable result if we can use the ton-mileage basis instead of the mileage basis. The only difficulty is how to get at a proper basis.

THE PRESIDENT: It is moved and seconded that the Committee on Ton-mile Statistics be continued; that it confer with the committee of the American Railway Association, as to the mileage of switching engines, and make a positive recommendation next year.

The motion was carried.

MR. H. F. BALL: If I am in order, I would make a motion that the Executive Committee be instructed to consider the suggestions contained in the excellent address of our President this morning.

The motion was duly seconded and carried.

THE PRESIDENT: The noon-hour has now arrived and it will be necessary for us to consider the subjects under the noon-hour discussions. The first is "Long Locomotive Flues." The discussion will be opened by Mr. H. D. Taylor, S. M. P., Lehigh Valley R. R.

THE SECRETARY: I wrote to Mr. Taylor, suggesting that he open the subject, but he advised me, after the program was printed, that he would be unable to be present. I then wrote to Mr. T. S. Lloyd, S. M. P., D. L. & W. R. R., but he has not

replied. Perhaps Mr. H. F. Ball, S. M. P., L. S. & M. S. Ry., will open the discussion.

MR. H. F. BALL: I have no data with me in connection with this subject to show what mileage we are making on long flues as compared with the short ones, but I would say in a general way, where the conditions are the same, the long flues do not give any more trouble than the shorter ones. We have twenty-five passenger locomotives with 19-foot flues. They have the wide fire boxes, having between 48 and 49 square feet of grate area. In comparison with these engines, we have some 10-wheel engines with narrow fire boxes with 33 square feet of grate area, and 16-foot flues. The flues on these engines do not give us quite as much trouble as the 19-foot flues on the other engines, but we attribute the difference in the service of the two lengths of flues to the difference in the fire boxes, because we have found from our experience with other engines in other service, engines having both wide and narrow fire boxes and the same lengths of flues, that the engines with wide fire boxes give us more trouble as far as the flues are concerned.

MR. FORSYTH: I think Mr. Humphrey has had some experience with 20-foot flues. Could we not hear from him.

MR. A. L. HUMPHREY: Having, perhaps, gone to a little more extreme than some of the others, I might be able to throw some light on the long-flue question. About six months ago we got two Pacific-type passenger locomotives, very heavy type, and they have been in constant service ever since. The two were used for about two months between Chicago and Bloomington on passenger trains, making 256 miles per day. For the first two months I would say that the locomotives perhaps bothered us twice by leaky flues. They have wide fire boxes, 108 inches long by 72¼ inches wide, with flues 20 feet long and 2¼ inches in diameter. We transferred one of the locomotives to the Kansas division where we have water that is perfectly pure. That locomotive has been operating in good water regions ever since. To date we have had absolutely no trouble with that locomotive from leaking. The other locomotive, which operates in bad water, has bothered by leaking; but no more so than the locomotive with the narrow fire box with flues 2 inches in diameter, 16 feet

6 inches long. In my opinion it is a question of water and not the length of tube. Of course, we know there is a maximum limit that we will reach sooner or later, but so far as I am personally concerned I am not afraid in the least of the 20-foot tubes, 2¼ inches or 2½ inches in diameter. We use a ¾-inch bridge, 9-16-inch tube sheet and 11 wire gauge for the 20-foot tube, and so far as my experience goes, we have had excellent results; we have had no more trouble with the long tubes than with the short tubes.

THE PRESIDENT: Did you use the No. 11 tube for the safe end?

MR. HUMPHREY: The same gauge for the safe end. That does not, however, prevent leaky tubes, by any means, in the wide fire box which gives a great deal more trouble than the narrow box, but I can not say that the long tubes give any more trouble than the short ones.

MR. GEORGE L. FOWLER: It seems to me there is another question involved in the advisibility of using a long tube, and that is whether you get the worth of your money by increasing the length. The length of the tube is increased in order to evaporate more water. A number of years ago Mr. Henri, on the Paris, Lyons & Mediterranean Road, made an elaborate series of experiments with tubes of various lengths, and he found that there was no advantage, from an evaporative standpoint, in increasing the tube a length beyond fourteen feet. That does not apply to American locomotive practice, because his rate of combustion was very much less than anything we are using now. I think it was between forty and fifty pounds of coal per square foot of grate area. If you run up to twice that amount, you have more heat going through the tubes, and, naturally, you can use a longer tube; but the question also arises as to whether there is not a point where you can have a tube, the increased length of which will not be of any value. I do not know whether any experiments have been made to determine whether a 20-foot tube is of any more value than a 19-foot tube. I think before the length of tubes is increased, this question is well worth looking into.

MR. C. A. SELEY: I will take up one statement of our friend,

Mr. Fowler, that long tubes are put in to obtain increased evaporation. The length of tubes is governed by the design of the engine, and the wheel arrangement and wide fire box used in certain types require long tubes.

MR. F. M. WHYTE: If in the fire-box end of an engine, for even 16-foot tubes, the temperature is 800, 900 or 1,000 degrees, and the temperature of the water in the boiler is less than that, it should be possible to get some heat through the tubes at the smoke-box end. If the tubes are not as efficient on that end as on the other, and we can get some heat from them there I think that we should take advantage of it.

MR. HUMPHREY: As Mr. Seley says, it is the design of the engine we must be governed by. With the Pacific type I spoke of, it is necessary to have the length, and in order to obtain it it would be necessary to put in long tubes. If there is no objection to the long tube, why not put them in and obtain what radiation you can or heating surface you get by that extra length? We have in these locomotives at the present time six feet from the front of the flue sheet to the exhaust nozzle. We felt that was as far as we would care to experiment; that is the maximum distance.

MR. DAVID BROWN: Is the engine a free steamer?

MR. HUMPHREY: Yes, very much so; in fact, I can say they are the best steamers we have on the road. They are able to handle the trains better. They are 22 by 28 engines. Figured on the ton-mile basis, they are the lightest in the consumption of fuel of any locomotives we have hauling the same trains.

MR. F. M. WHYTE: If Mr. Ball or Mr. Humphrey has measured the temperature in the smoke box in connection with the long tubes, it would no doubt be valuable information for all of us to have.

MR. H. F. BALL: I have not any data on that subject at present, but propose to get it.

MR. HUMPHREY: We have not, either; I intended to take that question up, in fact, have done so, but I did not come prepared to say anything on the subject and did not bring any data with me.

MR. WHYTE: When the temperature is taken, care should be exercised in noting the position of the fire door, whether open or closed, when the temperature in the front end is read. We found while taking some observations that when the fire door was open the readings might be 400 or 500 degrees; with the door closed, or soon after, the temperature would be 800, 900 or 1,000 degrees.

MR. FULLER: I would like to ask Mr. Humphrey what his experience has been with 20-foot flues, 2 inches in diameter, in high pressure boilers as compared with the short flues under the same pressure; also from his experience whether he has found it advisable in the use of the long flue to increase its diameter, and if he does not have more flue leakage with the long flue under the same conditions than with the short.

MR. HUMPHREY: I stated in my first remarks that we did not use 2-inch tubes of that length. The longest 2-inch tube is 16 feet. As you increase in length, I think you should increase in diameter of the tube, in order to add strength to the standing qualities of the tube. If you do not, I believe the vibration of the tube will cause it to leak. I have heard it said, of course, that there is no vibration in a tube, but I believe there is in a light tube. With a 20-foot tube, I would not advocate anything less than 2¼, and perhaps 2½ inches would do better.

MR. FULLER: I would like to ask if any of the members present have in service practically the same style of boiler and steam pressure, using an 18 or 20 foot, 2-inch flue in one boiler and a short (not over 15 foot, 2 inches) flue in the other boiler; if so, if they have any data to show the comparative service rendered by the use of the long flue and whether or not the long flue gave any more trouble than the short flue.

MR. H. F. BALL: The first lot of our large passenger engines was equipped with 2¼-inch flues, and last lot with 2-inch flues. The engines are the same in every respect, except in the diameter of the flues. We took the precaution on the last lot to obtain about the same amount of flue area. We can not find that there is very much difference in the service of the flues.

PROFESSOR GOSS: The heating surface was constant?

MR. BALL: Practically so. We made an experiment with two

large passenger engines of a lot of thirteen engines which were equipped with 2-inch flues, using the same flue centers as were used in a former lot of engines of the same size having 2¼-inch flues. This was done with the idea of obtaining larger bridges, believing that with the increased water space we would get longer service out of the flues. We did not find that they gave any longer service than other engines of the same class having a greater number of flues with smaller bridges. It appears that the smaller number of flues have more work to do and their life was consequently reduced.

PROFESSOR GOSS: It goes without saying that if the length of the tube can be increased, other things remaining unchanged, the performance of the boiler will improve. The cost of such improvement is to be measured by the new difficulties which appear when the length of the tube is increased. These, I fancy, are chiefly matters of maintenance. Are the long tubes more difficult to keep tight than shorter ones? Do they retard the draft? If not, then it seems to me, the argument is very strongly in favor of the more general use of longer tubes.

MR. D. VAN ALSTYNE: If there is no objection to a long tube in service, there is something to be gained in heating surface. The tests made by the committee on boiler design show that where tubes were plugged up at the ends with fusible metal inside, they melted the fusible metal at 450 degrees, at the front end of 18-foot tubes. The tube could only get its heat through radiation or superheated steam, from surrounding tubes. Therefore, there must be plenty of heat for the generation of steam.

PROFESSOR GOSS: It is well known that the smoke-box temperature of locomotives is sufficiently high to impart heat to the water in the boiler if the heating surface can be supplied over which to carry the gases. The heat is there; what we need is a suitable mechanical arrangement for utilizing it.

MR. QUEREAU: I move that the discussion on this topic be closed.

Motion seconded and carried.

THE PRESIDENT: We will now take up topic No. 2, "What is the most satisfactory way of setting flues in the fire-box tube

sheet, and what is the best style and form of tool for setting and repairing them?" This topic will be opened by Mr. P. H. Minshull.

MR. P. H. MINSHULL: In the consideration of the subject, "The most satisfactory method of setting flues," there is considerable difference of opinion. A successful practice is as follows: The holes in flue sheet should be as nearly perfect as possible and a properly annealed copper ferrule inserted and rolled, the boiler then being ready for the flues. The ends of the tubes should be swaged and afterward annealed; grind off all scale from that part of the flue which will enter the flue sheet; drive the tube through the sheet the proper distance, and expand it with a tapering pin. They should then be rolled with an expander and beaded with a pneumatic hammer, after which they are lightly rolled. If this method is conscientiously carried out by a competent workman, the results will be satisfactory. No copper ferrules are used in smoke-box end, and should the holes be too large for tubes, use a shim of "Russia" iron.

The best of material and the utmost care of a competent mechanic in applying a set of flues are sometimes disappointing in their results, from the carelessness of an engine crew or fire cleaner, who will ruin a set of flues in a very short time.

MR. MILLER: Mr. President and gentlemen: I am somewhat of an iconoclast on the present method of setting flues. It seems to be, from the various committee reports, particularly our committee of 1901, I believe, the almost uniform practice is to follow what Mr. Minshull has said. I have given the matter considerable personal attention, and I believe that not only is it unnecessary to use the roller expander in setting flues, but that it is a positive detriment to both the life of the flues and flue sheet. I have tried it, but unfortunately the experiments are not far enough along yet to determine whether it is necessary. I use nothing but the Prosser expander. The work is a little more laborious, but from the results which have been obtained so far, they are fully equal to the results obtained by our previous practice, with the additional advantage that the flue is not thinned in the sheet. It is a very easy matter for a man who is a little incompetent, or a little careless, to reduce the thickness of the flue appreciably so that

it can be felt with your fingers, and when you come to measure it, it is very perceptible. There will be a difference in the same size hole of 1-16 of an inch in diameter on the inside of the flue. Ask any boilermaker or roundhouse worker on flues how many times he can roll the flues and he will tell you three or four times is as much as he can do, and then they must come out. If that is the case with a roller expander, it looks to me as if it is a bad tool to use, and that is the reason I have tried this. There are many factories making stationary boilers that under no consideration would use a Dudgeon roller. The success in their case is as great as the firms that use the Dudgeon roller either exclusively or partially. The matter, however, is very largely in the hands of the men who do the work. In the engines referred to, we have issued instructions at all points not to use a Dudgeon roller upon them. How closely our instructions have been followed, I am not able to say, but the flues since they have been turned out of the shop have given us no trouble whatever.

THE PRESIDENT: Are they new engines or old flue sheets?

MR. MILLER: The engines in which we tried it had new flue sheets, the reason for which was with the old flue sheets it was a question whether we got the holes true enough to stand using the Prosser roller alone. I will say, also, that the use of the roller expander distorts the holes in the flue sheets, while the use of the Prosser expander does not.

MR. DAVID BROWN: With new flue sheets it is not necessary to use the expander at all, if I understand the matter correctly. If you have a new flue sheet with a 2-inch flue, swage the flues down, making the hole in flue sheet 1 15-16 inches, and get a copper liner, number 18, to begin with, roll that a little in its place to secure it, the flue is swaged down to fit in snugly, then rolled and beaded, and it is not necessary to use a Prosser expander, because there is a shoulder back of the flue sheet already. With new work that is the best practice, I think. The roller we use is one we make, somewhat on the same principle as the Dudgeon, but with the roller slightly on an angle, not parallel with the spindle. We find it much better, but it is on the same principle as the Dudgeon.

Professor Hibbard: If a man has yellow eyes and yellow skin, in other words, jaundice, the doctor does not prescribe liniments for the eyes or poultices for the skin — he treats the liver. It seems to me that the matter of setting flues in tube sheets is based on the same idea. You do not want to treat the symptom, but the cause of the disease. Something has been said about 20-foot tubes and whether they give more trouble than the shorter tubes. They ought to give more trouble, because you have more feet of tubes to expand and contract. Naturally, they will tend to pull back after being set in the tube sheets. It seems to me that the difficulty with the tightness of the tubes is simply a symptom of a disease which should be treated elsewhere; in other words, if you are going to put metal in your tubes, which is going to be hot and cold, hotter than the outside barrel of the boiler, for instance, hotter than the water — and they will be hotter than the water in proportion as more scale forms — you want to provide some way by which they can lengthen and shorten, without pulling in and out of the flue sheet. You will find on some recent, very large boilers, that the tubes which are nearest the outer shell of the boiler, will perhaps be not more than 2½ inches from the outer shell of the boiler, whereas they ought to be 4½, 5 or 5½ inches, possibly. One reason is that the tube sheet, particularly the front tube sheet, may be allowed to act a little as a diaphragm, so that as the tube lengthens and contracts, the tube sheet can be allowed to bend a little as a diaphragm and not cause it to pull back and forth in the hole, where you do not want it to pull back and forth. I believe you will have less trouble with the leaking of the tubes in the tube sheet, if you give some room for diaphragm action, so that the tubes can be contracted and expanded. That may be obtained not only in the tube sheets but in the rest of the line of action between the front end of the boiler and the back end of the boiler. For instance, keep the top line of stay bolts for the back fire-box sheet a little down from the crown sheet, a little away from the side sheets, so as to give some diaphragm action back there. In other words, it is one of the axioms of boiler design that you will have contraction and expansion in the shell, due to changes in temperature in the shell, and that contraction and expansion you must allow, and if you make a design so that it is not allowed, there will be, somewhere, cracks, loosen-

ing up, leaking of tubes, etc., and the place to cure the jaundice is to treat the liver and not to poultice the skin or put liniments upon the eyes.

Mr. George L. Fowler: The matter of making the tube sheet so that it could come and go with the expansion of the tubes was tried in Europe a number of years ago and found to be a failure. The way in which it was done was in the use of a corrugated tube sheet by which the expansion of the tubes could be readily compensated for.

Mr. Miller: It is curious sometimes how the experience varies on different roads. This fact has within it one of the largest benefits which accrue to us from our meetings in this convention. In exact opposition to what Mr. Fowler has just stated, I would say that we had two engines a number of years ago in which we could not keep the flues tight — shell corn would come through them, as easily as water. One of our boilermaker-foremen, under whose direction the engines were, conceived the idea of making a copper expansion joint, extending from just above the top row of flues all the way around to the bottom. After it was done, we never heard of a leaky tube on these engines, and the engines were under my jurisdiction for some two years. They were notable for freedom from leaky flues. They passed away from the division I had charge of and I do not know what became of them, but the scheme in those two engines did the work for which it was designed.

[illegible]: If I understand Mr. Miller correctly, he condemns the roller expander in expanding flues and favors the Prosser expander. I was in hopes some of the other members would take up the question of the roller expander, but as no one has done it I am forced to say that I do not agree with Mr. Miller in that particular. We are using both the Prosser and the roller expanders. We have found that we are able to obtain as good results with one as with the other. At some points on our line [illegible] used one [illegible] the other with equally good results and [illegible] it is [illegible] the manner in which the tool is used [illegible] a flue if improperly used. [illegible] styles of flue tools, [illegible] the use of

the same or oversetting the flue, which naturally decreases its life. Personally, I can not help but stand up for the roller expander. We have received the best of results from the use of it, and we believe flues are more likely to be damaged by a careless man with a Prosser expander than with a roller. In our opinion flue troubles are not all chargeable to the men who set the flues, but a great deal of the trouble is due to exposure on the road and ash pits. The flues in service require as much attention as the manner in which they are being set.

MR. J. L. LAWRENCE: This matter of leaky flues, and the matter of repairing flues, has been pretty well discussed, and I do not know that I can adopt any superior methods for curing the troubles than in the past, simply because I do not know, from what has been said, what to do to meet the conditions. However, it occurs to me we are expecting results from flues to-day when we are not giving them the amount of attention which they require, due to the extraordinarily severe conditions. For instance, a few years ago we were setting flues practically in the same way we are setting them now, and the boilers were carrying from 125 to 160 pounds pressure. To-day we are running boilers at 200 and 225 pounds pressure, and as far as I know we are not setting the flues any better, nor repairing them any better, than before. In other words, the conditions of service have become more severe and the methods of caring for the flues have not improved in proportion with the increase of conditions.

Another cause of leaky flues is probably due neither to the setting or the repairing of the flue. The question of whether it is a long flue or a short flue, a high-pressure or a low-pressure boiler, does not enter into the proposition. I refer to the treatment of the engines at the ash pit. We all know that an engine will come to the ash pit dry, so far as the flues are concerned, and go to the engine house leaking. It occurred to me that the trouble was caused at the ash pit in dropping the grate to clean the fire, in the admittance of cold air to the flue sheet, thus causing an unequal amount of expansion and contraction. I would like to improve our conditions if any one can tell me how to cure that trouble, how to set these flues or repair them, on high-pressure boilers, so that they would not leak. I have trouble, like most of

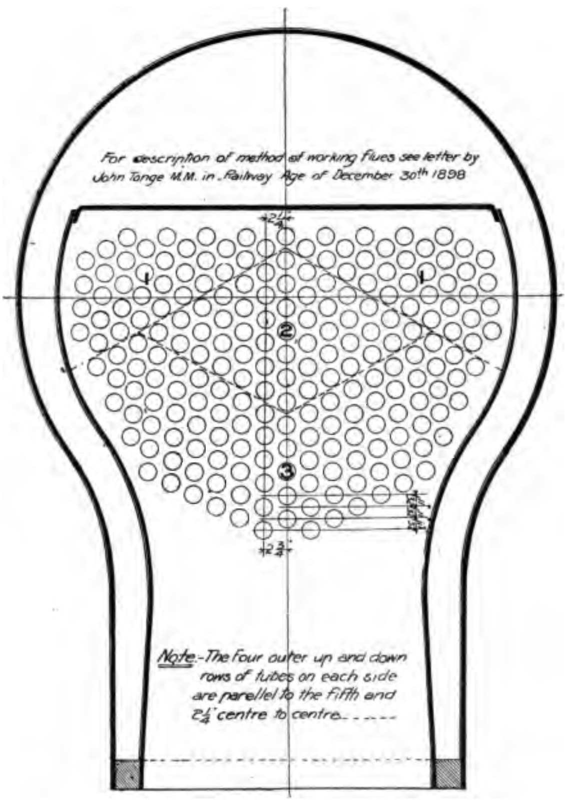
our members, with leaky flues, and I am frank to admit I have got to the end of my string and do not know what to do to stop them from leaking. I am inclined to think we will have leaky flues as long as we run locomotive engines.

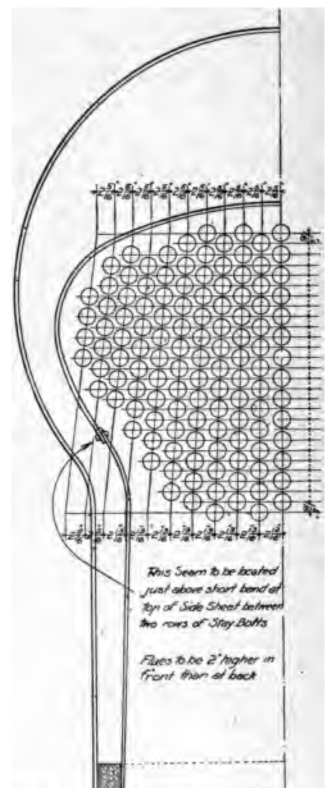
MR. TONGE: I think you will have leaky flues so long as you finish the work with a flue roller. For the past twelve years we have never finished a flue with a roller. They have been finished with a Prosser expander during that time, and while I would not like to say that we have had the best success in the world, yet we do claim that we have attained a degree of excellence in flue-setting unsurpassed by any other railroad. We know that our flues are abused at terminal stations, over the ash pits and at division points where the engine has to ascend a considerable grade after fire is cleaned. This abuse is most severe in winter months.

The preparation of flues for the flue sheet should be very carefully done. The removal of scale from the end of tube fitting in back sheet and the use of proper appliances for fitting the flue to the sheet are very important. It is also very important to have the proper width of copper ferrules not less than ⅞ inch in length. I have always found that the narrow ferrule is not satisfactory in flue work. If you will place a few flues in the flue sheet and get inside of the boiler so as to notice the different action between the narrow and the wide ferrule, you will find that the narrow ferrule turns away from the flue, and you will notice that in the action of the wide ferrule under operation, in every instance, the ferrule lays down over the flue, thereby preventing the possibility of any sediment getting in between the flue and flue sheet. We have followed this practice for the past twelve years and we do not find any more trouble in keeping the flues tight in a boiler carrying 200 pounds pressure than we do in one carrying 125 pounds pressure.

When having to remove tube sheets on standard engines we follow the practice as outlined above, the design herewith showing the method and practice which we have followed. All engines on the M. & St. L. Railroad have tube sheets so designed.

In adopting this method on one class of engines we left out thirty flues and on another class fourteen flues. We find that





Sketch showing principle of laying out Flue Sheets and Location of Seam of Crown and Side Sheets

we have improved the circulation and steaming capacity of engines by putting in flue sheets so designed and leaving out the number of flues mentioned.

Mr. Humphrey: Notwithstanding we are approaching an hour when this discussion should close, I do not think we can afford to drop it at this moment. I do not think this Association can afford to let the minutes of this meeting stand as showing it is incompetency which causes flue trouble throughout the country. As far as the remarks made concerning leaky flues and the proper treatment of them go, I would ask how the gentleman is going to remedy the troubles in a case like this: On two districts of a road, where there will be locomotives entering the same terminal, one from the north and one from the south, the locomotives being taken care of by the same workmen, the flues put in by the same people, receiving the same care from the one pit, in fact, having the same attention throughout, the one running south comes in leaking nearly every day, and the other, that runs north, will run twelve months without causing a leak. That shows it is not incompetency, but that there are local conditions which you must overcome, and in considering the flue question, you must take into consideration the local condition, or the seat of the trouble that Professor Hibbard spoke of. I believe the diaphragm suggestion is one for us to pay attention to, and one which will help solve the flue trouble. On some of the districts on our road we have absolutely no trouble so far as flue leaking is concerned. On other districts, if we have locomotives run thirty days without giving up a train, we think they are doing remarkably well. You can not tell me it is improper workmanship. If it is, it is peculiar that the workmen should select all the locomotives on one division on which to perform bad work.

The delays of trains, so far as the Chicago & Alton is concerned, is something I am not proud of; it is expensive and is caused entirely by the boilers leaking, not from failure of machinery, but from the boilers. On two-thirds of our road we have practically no trouble at all. Where we have bad water we have lots of trouble, and it is for us to determine what is the cause, and then remedy it and not put it off as a technical point and unimportant.

MR. R. H. SOULE: In 1897, when I left the Norfolk & Western Railroad, this whole subject was under investigation, and we came to the conclusion it did not make much difference whether the Prosser or Dudgeon expander was used, but we did discover something which largely influenced the life of the tubes after they had once been set. It had been suggested that the beading tools used over the road in different roundhouses were not uniform as regards the contour of the curve on the shoulder. Samples of these beading tools were sent to Roanoke and compared, and it was a curious object lesson. They formed the most battered-up lot of tools you ever saw; there was no uniformity in them. Some would give flat beads, and some circular beads, and there were all the intermediate forms. The conclusion was that what was needed was to establish a standard contour line for the edge of the horn on the beading tool; to provide the necessary number of templates, distribute them over the road, and require that the shoulders should all be ground to these templates. This came up before I left the road, and had not been acted on, so I can not give any results.

MR. HENRY BARTLETT: We have done two things on our road that have helped us in this matter; one is to do away entirely with the use of the Prosser expander. We found that a dangerous instrument in the hands of a man, if he was not very careful, and it took a pretty good man to work the tool right. It has to be hit square in the middle or damage is done. Another thing was to require our engineers to close the damper on all engines on stopping on sidings or ash pits. This has resulted in a great reduction of leaky engines. We have a flue in use called the spiral corrugated tube, a set of which has been in service three or four years on an engine and no leakage has resulted in any way. They also show economy in coal, and reduction in smoke. It occurs to me that the way these tubes are made provides a good deal for contraction and expansion and prevents leakage.

MR. ANGUS SINCLAIR: There are certain things that people generally believe should never be in the hands of children or fools. There are certain tools that I think, from my own experience in the boiler shop, should be excluded from a boilermaker's outfit, and if that were done there would be less trouble with boilers and

with flues. One is a drift. The use of a drift is one of the most pernicious practices that has ever been followed in any boiler shop. The next destructive tool, in my opinion, is the tube roller. In the hands of a reckless boilermaker or fire-box butcher, the flue roller is one of the worst things that ever was tried, and I think causes more leakage than all other causes combined, except that of blowing cold air through the flues when the fire has been drawn.

PROFESSOR HIBBARD: I do not want to leave the idea with you that you have only one medicine for your liver complaint. I think the diaphragm idea I spoke of is not the only medicine for the flue jaundice. I do not see how the diaphragm idea is going to help the central tubes very much. If we go back to the original idea of what causes the tube leakage, the contraction and expansion of your tubes, the diaphragm idea would still let some of the central tubes be leaky. It seems to me our friend just hinted at a remedy, which lies in increasing the bridge so there is opportunity for the water to have a circulation up through the tubes. No one knows how the water circulates among the tubes. We think it goes down outside near the shell and shoots up through all the tubes. It may hit some and not others. If the cold water does not hit some of the tubes they will become very much heated and push out. If you increase the bridge, so there is more water space between the tubes, you will be more likely to keep the tubes evenly cool, so there will be no unequal contraction and expansion of some tubes. The larger bridge will give you a little more metal between two holes in the tubes, between the tube sheet, so that there is more stiffness left in the sheet. It must have some springiness to keep hugging against the tube and back ferrule.

MR. TONGE: In removing all of our tube sheets, flue sheets, front sheets and fire-box sheets, we strike a center line inclining over that so that the upper bridge is 9-16 inch and the lower bridge 1⅛ inches, and remove in the upper row something like four or five tubes so as to stiffen that section of the back sheet. As a result we find our holes maintain their true circle.

MR. R. D. SMITH: We have been following up this matter of better care of locomotive boilers for some time to find a cure for cracked side sheets and leaky flues. As a preventive for the cracked side sheets, we are trying to get more intelligent wash-

ing out of the boilers, and we have found good results from putting it in the hands of a specialist.

In the care of the flues we have given particular attention to putting water in the boiler after the engine has arrived at the clinker pit. It has been our experience that but few engines arrive at the clinker pit with leaky flues, but the flues start leaking while the engine is between the clinker pit and the roundhouse. The accepted theory for the leaky flues is that it is done by the hostler opening the fire door and putting on the blower when he cleans the fire. We have decided that that is not the real cause for the flues leaking.

Given a set of flues properly set by any given method that arrived at a clinker pit tight, and are leaky when they arrive in the roundhouse, an examination of the flue sheet and the fire box will show that the flues and stay bolts leaked at the side and at the bottom on which the injector was used. We made some tests with thermometers to show the reduction in temperatures caused by putting water in the boiler; I do not recall just what the drop was, but it was something like 100 degrees between the check and the fire box. We have lately adopted a rule that no water shall be put into a boiler after an engine arrives at the clinker pit, unless there is a good fire in the engine and the blower on and circulation is kept up. In this way we have reduced our flue leakage very materially, and while we have only just gone into that, we feel there is a good deal to it.

Mr. Symington: I have noticed a practice on Mr. Sanderson's road (The Seaboard Air Line) in reference to setting flues, which has given remarkable results, and as he is not here I think you may be interested in hearing what it is. They cut a small ferrule from a tube and mash it down into a swage block, so that it can enter. They drive that ferrule into the tube that is worn out so that it will not hold — expand the ferrule inside the tube. If the bead is gone they bead over this ferrule. I have seen their engines with flues in them that ordinarily would have to come out, and by putting these ferrules in, which can be quickly and cheaply done, they can very frequently get three to six months more service out of the flues than before they adopted that practice.

The President: We are drifting from the subject of prop-

erly setting flues, and I hope members will confine themselves to the subject.

We have an engine with a set of the tubes Mr. Bartlett has mentioned, the Whitney corrugated tubes, and I think they have been in service five years. They have only been removed once. Where we had engines giving trouble with leaky flues, 2-inch flues, when we put in a new flue sheet we made the fire-box flue-sheet hole 1¾ inches and put 1¾-inch safe ends on the 2-inch flues. This gave us a heavier union between the flues and a better circulation next the flue sheet. It does not interfere with the engine steaming and materially prolongs the life of the flues.

MR. MINSHULL: I examined the engines which have those flues, a short time ago, and the flues were in very good condition. They were doing excellent service.

On motion the discussion on topic No. 2 was closed.

THE PRESIDENT: We have passed one paper, that on "The Best Type of Drawbar Attachment Between Engine and Tender," which is to be presented by Mr. Bartlett. It is for you to decide whether we shall continue on our noon-hour subjects, of which we have two yet unfinished, or go back to the papers outside of the topical discussions, of which there are two. We have only a short time left before adjournment. Some one has said that the best way to repeal a bad law is to enforce it, so that it will attract attention. For several years, I have advocated the cutting down of the number of discussions at our convention. There is a tendency to hurry them through. We ought to either lessen the number of subjects or else continue them as we are doing this. I agree with Mr. Humphrey that many of these matters are too important to be hurried through. If we confine ourselves to the program and discuss these subjects as they come along, we shall be confronted with the necessity of having fewer topics for discussion or holding extra sessions of the convention.

MR. A. M. WAITT: It seems to me that inasmuch as it is within seven minutes of the time for adjournment, it would hardly be fair to take up a regular paper, and I move that the remaining time be given to the next topical discussion.

Motion seconded and carried.

THE PRESIDENT: We will take up topic No. 3: "Grinding as a Method of Finishing Piston Rods and Crank Pins," by Mr. H. H. Vaughan.

MR. VAUGHAN: In talking of grinding as a method of finishing work, I will not refer to the grinding of about two years ago which was largely for the purpose of precision. At that time the grinding machines in use used a wheel about ¾-inch face, 12 to 18 inches in diameter, and the removal of metal was ordinarily very slow. I think at the Buffalo Exposition a machine was first shown having a grinding wheel with a 2-inch face, 24 inches in diameter, in which the grinding was performed against solid stops, in place of flexible stops, permitting a very high pressure of the wheel against the work, the uniform diameter of the work being obtained by adjusting the stops. This type of grinding has come into use and we have at our Collinwood shops one of these machines, which has been in use about six months. The machine is exceedingly heavily built, and I would judge from our experience it is necessary to have a very heavy machine to do that kind of work without chattering.

The most important question, of course, is the relative time of finishing work on the grinding machine as against running over one or more fine cuts in the lathe and finishing by filing. I have tried to obtain what we might call actual, fair figures on this work. The time taken, including putting the work on the grinding machine, which is done by air hoist, and finishing it, is about as follows: On piston rods, for 21-inch cylinder consolidation engine, 3¾ inches diameter, 42 inches on the parallel portion, the grinding occupied, from the roughing out, 16 to 18 minutes. As against that, I would estimate the time of turning and filing to be about an hour and a half; which is the result we obtained at other shops. We might improve that hour and a half a little if we went after it. As a matter of fact, to finish the rod properly by filing, it is necessary to run the finishing cut with a feed not much over a fortieth, probably not over a fiftieth of an inch, which makes a very slow operation. Valve stems, grinding from the rough cut, 10 or 12 minutes as against 45 minutes. Crank pins, 20 or 22 minutes, as against an hour or an hour and a quarter. This is a large main crank pin for the same class of engine.

In addition to finishing new work, we have also used the machine for the truing up of worn piston rods and valve stems. Of course, it is hard to give an average time for work of this class, as the rods may be worn more or less badly. On a number of rods the average grinding occupied thirty to thirty-five minutes. Time will develop if we are adopting the proper practice in that case. I think the best way would be to run a quick-roughing cut over the work when there is 1-16 to take off; but when you consider you have to take two machines, there is more time lost. In refinishing the valve stems, it takes twenty to thirty minutes.

All around, I would assume the saving on grinding, as against lathe work, to be between four and six to one, according to the job, the grinding only taking a quarter to one-sixth of the time occupied by the lathe. As against that we have the fact that the grinding machine must be an exceedingly heavy machine to stand the removal of metal at that rate. That makes an expensive machine, and I should be doubtful whether any shop not doing manufacturing work, not making new rods or similar parts to any extent, would be warranted in introducing the grinder. One point of interest is the finish on the rod, and so far as we can learn, it is, if anything, just as easy on the metal as the file finish.

Mr. Sinclair: As there is an evident desire on the part of our members to adjourn for dinner, I move that the further discussion of this subject be postponed until the noon-hour to-morrow, and that the meeting adjourn.

The President: Before putting that motion, I would like to announce that Mr. R. H. Soule, who is on our program for a topical discussion on Friday, will have to leave the city on Friday morning, and he will read his paper on Thursday, at the noon-hour, one of the first subjects to be considered at the noon-hour.

The Secretary: The convention will begin to-morrow morning at 9:30 promptly, and the report by Mr. Bartlett will be the first one considered; and the next paper will be that on "Electrically Driven Shops."

The meeting adjourned until Thursday morning.

THURSDAY'S SESSION.

President West called the meeting to order at 9:30 o'clock.

THE PRESIDENT: It was an oversight on the part of your President yesterday in not inviting the Past-Presidents to the platform. I understand it is one of the recommended practices of the Association. That they did not take places on the platform was partly their own fault. If there are any Past-Presidents in the room, we will be glad to have them come to the platform.

The first paper this morning is an individual paper on Drawbar and Buffer Attachments for Use Between Engine and Tender, by Mr. Henry Bartlett, S. M. P., Boston & Maine R. R.

MR. BARTLETT: Mr. President and Gentlemen,— I will not read the paper through, as it would consume considerable time. I assume most of the members have looked it over, and I will just read a short abstract.

You will note that the use of the spring buffer between engine and tender is not commented on with favor. While from a comprehensive canvas of the question numerous adherents to the design are found, there are still on the other hand many, including those who have experienced the heaviest and most severe service, who are strongly convinced that the device is far from satisfactory. Within the past few days, I may mention having received a letter from a motive power official, representing one of the large railroads, stating that the spring buffer arrangement had been found to be a dismal failure on recent large locomotives and that information was desired to the end of some satisfactory solution for the problem.

There is a growing feeling that the design has been adopted too much in the nature of a fad, and, while having to confess that my own road has been somewhat in style, I am satisfied with many others that the device fails in its application to heavier power and that, as time goes on, its field of usefulness will become smaller.

Two suggested remedies are mentioned on page 10 of the report. As to the first one, it is not quite clear to me at the present time whether it can be advantageously adopted or not. It is, however, my intention to make a trial of the adjustable wedge arrangement as shown in figure 19 at an early date and I regret that it has not been possible for me to do so before.

I feel that just a word of apology is due to some of the roads whose designs of draft gear I have taken the liberty to reproduce as illustrating extreme cases and that it is only fair to state that the present practice of these roads recognizes only the straight horizontal drawbar as proper.

Before closing I also want to again express my thanks to the several

motive power officials who so kindly furnished valuable data to assist in preparing this paper.

The paper is as follows:

AN INDIVIDUAL PAPER ON DRAWBAR AND BUFFER ATTACHMENTS FOR USE BETWEEN ENGINE AND TENDER.

BY HENRY BARTLETT, SUPT. M. P. BOSTON & MAINE R. R.

(An Active member of the Association.)

Topic. What is the best arrangement of drawbar and buffer attachment for use between engine and tender? What should be the form and relative strength of the drawbar to tractive power of engine, and what offset in the drawbar is permissible?

The status of the design of a proper draft connection between engine and tender is, at the present time, one of great uncertainty, and yet, viewing the rapid growth of modern power, no single feature of locomotive construction merits more serious consideration. In the past, this uncertainty has arisen apparently from the lack of general appreciation of the real forces concerned, and may still exist from our failure to recognize and employ such figures as dynamometer records have in the past suggested, as well as such other data as would have evolved from an earlier and more open interchange of ideas.

Great magnitude of forces considered. It is a vital consideration at the start to clearly appreciate the scope of the problem, and the magnitude of the forces which we are called upon to recognize. Only within a comparatively short period of time have careful tests been made in the measurement of stresses produced in drawbar attachments of any sort, and the results of these have indicated figures much larger than anticipated. Relative to these tests, Mr. Marshall * comments as follows:

Mr. Marshall's recommendations. "It is found, out on the road, with a skilful engineer on the engine, that the tensile and buffing stresses seldom exceeded 50,000 pounds and 80,000 pounds, respectively; with a less skilful engineer, however, the stresses increased to about 70,000 pounds and 150,000 pounds, respectively. An engine coupling onto its train gives stresses ranging from 65,000 pounds to over 142,000 pounds; a switch engine coupling onto the dynamometer car standing alone gave a stress of 103,673 pounds; when a string of loads was behind the car, the switch engine coupling on gave a buffing shock of 199,482 pounds; and thirty loaded cars, moving at about six and one-half miles per hour and coupling onto the ten loads with brakes set, gave a shock of 376,492 pounds. It would seem reasonable, in

* Report of Committee on Draft Rigging in relation to whole cars.— Proceedings of Western Railway Club, May 20, 1902.

view of the above figures, to require draft gears to be capable of withstanding tensile stresses of 150,000 pounds and buffing stresses of 500,000 pounds."

Investigation of Mr. Parke confirms these figures.

In demonstrating the effects of elastic impact between cars, Mr. R. A. Parke refers to similar tests where a maximum pressure of initial impact of 370,709 pounds was followed in reaction by a tension in the drawbar of 73,828 pounds where spring draft gear was used. These figures confirm, from another standpoint, the results previously noted. Different railroads have apparently made such widely varying provision for resisting these forces in the drawbar attachment of locomotives that it seems especially fortunate that the above authentic figures have finally been obtained.

Inquiries sent out relative to state of the art.

As an initial step in this investigation, it seemed important to obtain as concise information as possible concerning the present state of the art, and accordingly inquiries were addressed to three prominent locomotive builders and to twenty-five railroad companies, selected as far as possible with a view to covering all sections of the country, asking for representative designs pertaining to the first clause of the subject, together with comments thereupon. In response to these inquiries, a full quota of replies was forthcoming, wherein were presented past experience, present practice and incidental recommendations for the future, with accompaniment, in almost every case, of descriptive matter and blue-prints.

Fundamental features of draft connection.

The fundamental elements of a drawbar attachment between engine and tender are essentially three:

1. The drawbar itself which receives the tensile stresses.

2. The buffers, or chafing irons, which receive the stresses of compression, or impact.

3. The safety device, which comes into play only in case of failure of the drawbar.

Designs repro- ced showing

An examination of the designs, herewith reproduced from prints very

namely, that of the safety appliance, we note that many roads still use the time-honored safety chain. There are interesting deviations from this practice, however, and attention is invited to Fig. 5, illustrating the practice of substituting for this office a pair of bars, similar in appearance to the drawbar itself. From efficiency in service and facility in coupling up the tender, this would seem to be a commendable practice. An interesting adaptation of the coil spring in connection with the safety chain between engine and tender to assist in absorbing the shock incident to the parting of the drawbar, is shown upon the New York, Ontario & Western design, Fig. 8.

Unique safety appliance.

Coming now to that part of the subject, "What should be the form and relative strength of drawbar to tractive power of the engine and what offset in the drawbar is permissible?" some little ambiguity arises from the duality in conception of the expression "offset." I find that, in the majority of cases, this is construed as meaning the difference in horizontal plane of the ends of the bar. Obviously the tendency of such inclination of the drawbar is relatively to elevate or depress the front end of the tender, and, for a constant length of drawbar, such tendency increases with the increase in difference in height, in the manner suggested in the graphical formulæ, Figs. 1 and 2.

Drawbar form and strength.

The lifting effect has these objections: weight is transferred from the front truck of the tender to the rear of the engine, whose spring rigging has not been designed to carry this additional burden, and since this force is a function of the drawbar pull of the engine, it is necessarily intermittent. Moreover, the removal of weight from the tender has been known to cause sliding of tender wheels when brakes were applied. However, since the increase of stress in the drawbar due to this inclination is merely the difference between the horizontal stress, and the resultant of this with the lifting force, and is comparatively slight, this consideration is not vital so far as the strength of the drawbar itself is concerned.

Therefore for purposes of discussion, it seems more important to adhere to the other construction of this term, and to specifically define offset, as the maximum distance which the neutral axis of any section departs from a straight line connecting the centers of the drawbar pin bearing surfaces, thus dimension "A" in the subjoined cuts.

Offset defined

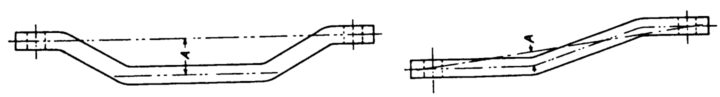


FIG. 3

As far as this offset is concerned, it may, of course, be made anything that seems necessary, if adequate strength is provided. This means that if offset is unavoidable in conforming to existing conditions upon old footplates and tender draw castings, then proper consideration must be given

view of the above figures, to require draft gears to be capable of withstanding tensile stresses of 150,000 pounds and buffing stresses of 500,000 pounds."

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Designs reproduced showing variety in arrangement.

An examination of the designs, herewith reproduced from prints very kindly furnished by different railroad companies, reveals the fact that uniformity of practice has not obtained, nor, in general, has sufficient capacity been provided for modern requirements. With the three fundamental elements always in mind, the designs seem to have drifted along various independent lines, as local conditions or personal convictions have dictated.

Drawbars, spring buffers and safety devices.

It is to be noted that in the past drawbars have been used wherein the difference in level of drawbar ends has been as great as 7 inches. However, the universal verdict of the present time is in favor of the straight horizontal drawbar, and representative recent designs from the same sources as the above mentioned now rigorously adhere to the latter practice. Illustrating the second element of the draft connection, you will note that spring buffers have been largely used with various dispositions of springs for the purpose of taking up the slack, while other roads still adhere to the rigid chafing blocks. With reference to the third element:

† Elasticity of Draft Gear.— Proceedings of Railway Club of Pittsburg, March 28, 1902.

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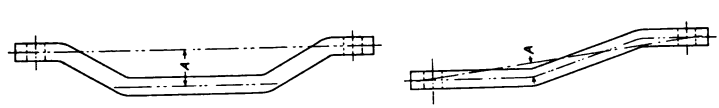

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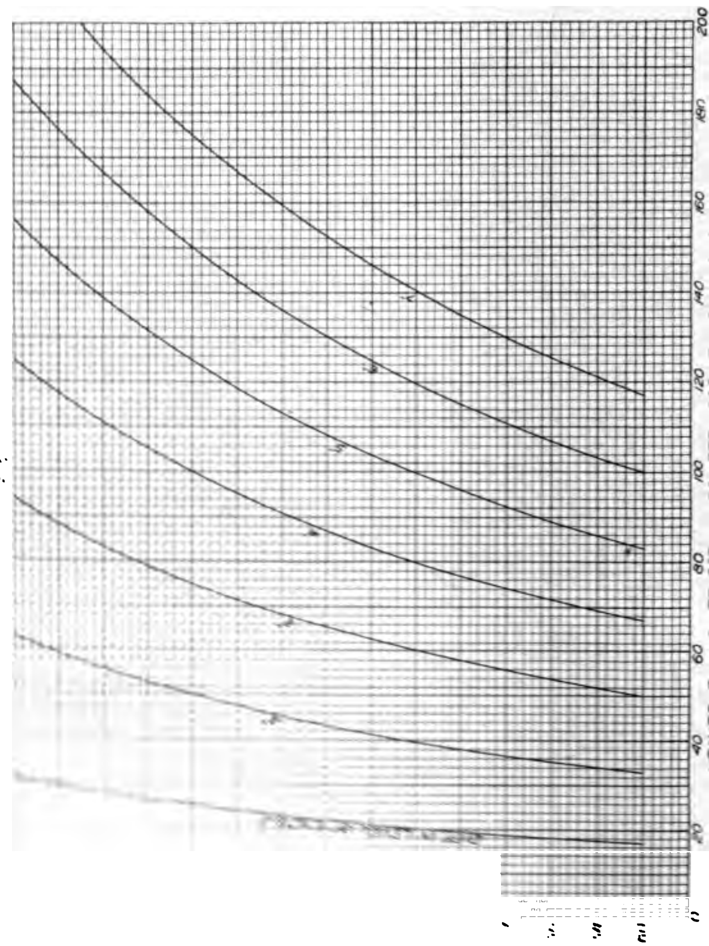
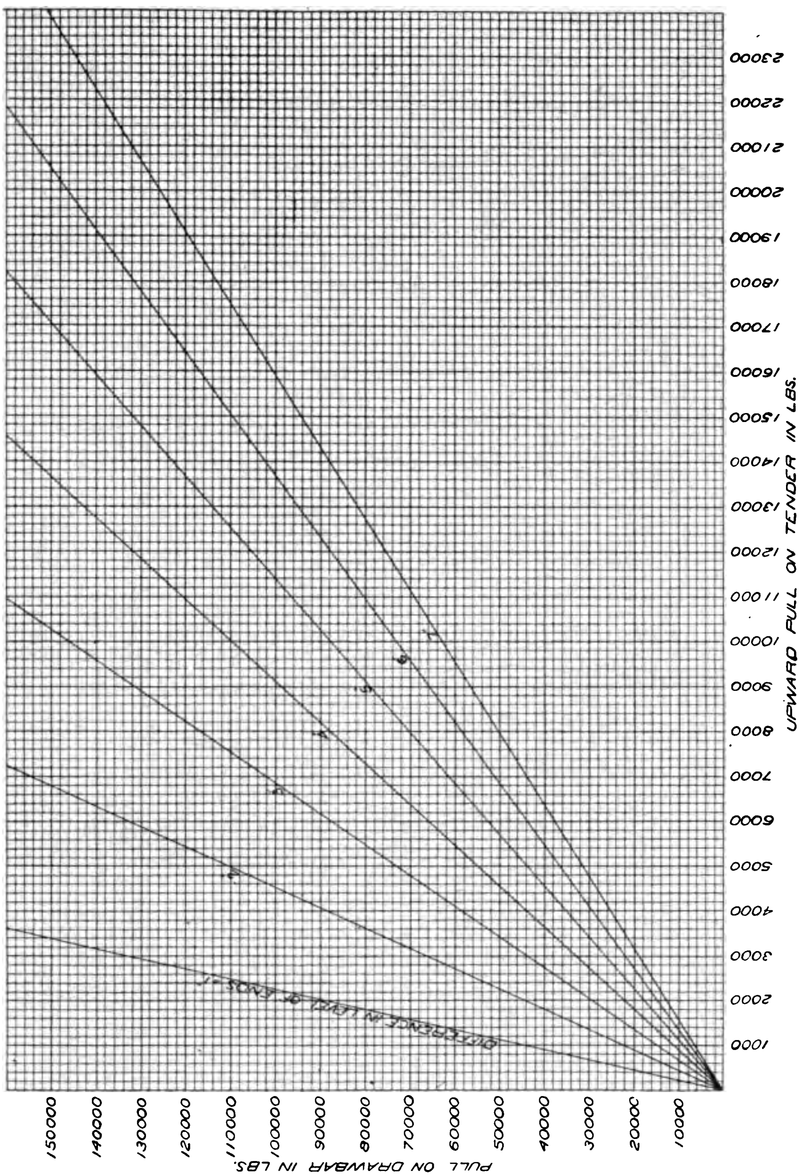


UPWARD PULL ON TENDER IN LBS. PER 1000 LBS. DRAWBAR PULL
20
40
60
80
100
120
140
160
180
200

FIG. 2

RELATION BETWEEN DRAWBAR PULL AND UPWARD PULL ON TENDER FOR A DRAWBAR OF 44" EFFECTIVE LENGTH.



to the stress due to the bending moment, in addition to that credited to the drawbar pull. This bending moment is, of course, the product of the dimension " A " into the drawbar pull. The extreme fiber stress, due to bending, is obtained by the usual formula:

$f = \frac{My}{I}$ whence the combined stress becomes

$f_{,} = \frac{My}{I} + \frac{P}{A}$ where M = Bending moment.

y = Distance of extreme fiber from neutral axis.
I = Moment of inertia of section with respect to its center of gravity.
P = Drawbar pull.
A = Area of section.

To illustrate this, take an actual case:

Tractive power of engine is 21,600 lbs.
Greatest offset = $3\frac{1}{4}$ inches.
Drawbar is $4\frac{1}{4}''$ wide and $2\frac{3}{8}''$ deep at point of greatest offset.

$$f_{,} = \frac{21{,}600 \times 3\frac{1}{4} \times 1\frac{3}{16}}{\frac{4\frac{1}{4} \times (2\frac{3}{8})^3}{12}} + \frac{21{,}600}{4\frac{1}{4} \times 2\frac{3}{8}}$$

$$= \frac{21{,}600 \times 3\frac{1}{4} \times 1\frac{3}{16} \times 12}{4\frac{1}{4} \times (2\frac{3}{8})^3} + \frac{21{,}600}{4\frac{1}{4} \times 2\frac{3}{8}}$$

$$= 17{,}570 + 2{,}140 = 19{,}710 \text{ lbs. per sq. in.}$$

At the point of maximum offset, the most favorable section to resist bending is that wherein the long axis of the section is in a vertical plane. This observance is rare, and a reason why it may not better be utilized lies in the fact that where an offset is made, it is to avoid contact with some rigid part, and to increase the radius of gyration in the vertical plane tends to remove the center of gravity still farther from the line of direct stress; in other words, there is more offset than there was before.

All of the foregoing only serves to emphasize the truth that offset is undesirable, as it entails additional weight of metal, and in general a cumbersome design. Curves are presented herewith, illustrating the manner in which these quantities are interdependent.

Form of drawbar.

As to the form, since the later tendency is correctly toward the straight bar, the rectangular section with its long axis in the horizontal plane is most favored. It is suggested as good practice to reinforce each end of the bar by hubs in a manner to lengthen the pin bearing within a reasonable limit. It will be noticed in the arrangement reproduced herewith, as Fig. 7, that these hubs have been placed upon opposite sides of the bar, apparently with a view to minimize the effect of the necessary inclination.

A form of drawbar end, which is employed upon the Pennsylvania railroad, the B. & O. and several other roads, is worthy of note. In this the pinholes are rounded in the vertical plane section as indicated below.

The practice in connection with the use of this bar is to bring the engine end of the bar three-fourths of an inch high at the start, so that when 1½ inches of metal is worn or turned off of the tires, this end will

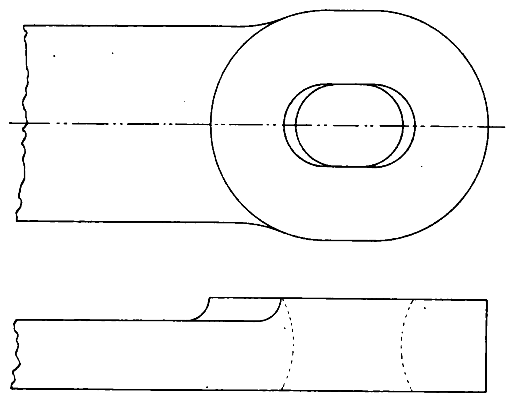


FIG. 4

stand correspondingly three-fourths of an inch low, neglecting consideration of wear on tender wheels.

The apparent decreased pin-bearing surface brought about by so rounding the holes in the bar has given rise to question as to the propriety of this practice, yet the fact that no ill results have been experienced with the use of a reasonably long radius vertically would seem to justify the practice. Moreover this form has a tendency to confine the center of stress near the center line of the bar.

In considering the relative strength of the drawbar to the tractive power of the engine, a comparative table was thought to be of interest, and your attention is now invited to the variation of practice therein revealed. **Drawbar strength.**

From the results of these tables, as well as from very sensible advices received from numerous motive power officials, it would seem reasonable to recommend that the working stress should be 4,000 pounds per square inch of section for straight drawbars. It must be recognized, however, when large offsets are necessary, concessions in the factor of safety must be made, and in such cases it would be reasonable to set 12,000 pounds per square inch as the maximum permissible limit. Taking the customary figure of 28,000 pounds per square inch as the probable ultimate strength for repeated stresses of tension, this would indicate that the strength of the drawbar is from 7 times to 2⅓ times the tractive power of the engine. **4,000 lbs. working stress.** **12,000 lbs. for offset.**

While this relation of tractive power to strength of drawbar was suggested in the subject of this paper, it does not appear that the ratio should be considered alone. It would seem rather that a limit of working stress, used in conjunction with some rational assumption relative to stresses due to shock and reaction arising from the sudden application of air brakes, for instance, should receive greater consideration.

he spring uffer.

Now, for the consideration of those parts whose office it is to care for the buffing, or compressive stresses, it is well to consider the so-called spring buffer at the start. Among the first of the accompanying illustrations this device has been shown in various forms in a general way. Fig. 14 gives the form in which the spring buffer appears on about seventy-five per cent of the roads where it is used.

lementary atures of this evice.

The elementary features of this device may be mentioned with reference to Fig. 14 as follows: The buffer (a) with its hollow cylindrical shank within which nestles the spring (b), which, in turn, finds resistance in the bottom of the buffer pocket (c) whose walls enclose the shank of the buffer. The base flanges of this pocket are bolted to the rear of the engine or front of tender as the case may be. Retaining screw (d) is provided to preserve the integrity of the spring buffer when engine and tender are uncoupled, and it is interesting to note the various ways in which this function is accomplished in a few departures from the conventional design.

The counterpart of this buffer is a plain block, or chafing iron, whose broad face is presumably always in contact with the buffer, to the end that the engine and tender are forced apart sufficiently to take up the slack between them and to provide means of absorbing the minor vibrations, or shocks, due to the restless movement between engine and tender.

iteresting epartures om conven- onal design.

A number of interesting departures from the usual design are shown. Fig. 15 shows an instance where the cylindrical shank of the buffer encompasses the buffer pocket. Fig. 16 presents a case where the center line of resistance passes far above the supporting base. This practice should be avoided, of course, as far as possible. Through an apparent belief that the practical possibilities of the single twin spring were exhausted, the design shown in Fig. 17 has been evolved. It is to be noted here, however, in certain positions of the engine upon curves, that undoubtedly the center of stress still passes through one or the other of these twin springs.

iortcomings the spring uffer.

I believe that nearly every motive power official will bear me out in the statement that no form of spring buffer has proven to be thoroughly successful, and I seriously question the soundness of the principle upon which this design, as it now stands, is founded. The investigation of the action of the friction draft gear between cars, as compared with that of the twin spring rigging, exhibits clearly the disadvantage of impact elastic to this extent. These same disadvantages appear in the spring buffer. Where we may count upon a buffing stress of 300,000 pounds to 500,000 pounds at times, it is obvious that the twin spring, whose capacity varies

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The spring buffer.

Elementary features of device.

Interesting departures from conventional design.

Shortcomings of the spring buffer.

from 20,000 pounds to 40,000 pounds, will be almost instantly closed solid, permitting the balance of the shock to be taken by the casting and the vehicle to which it is secured. To increase the capacity of the spring, even if practical considerations of coupling up would permit, means only to add a corresponding stress in reaction upon the drawbar during the initial period of restitution. To substitute heavy steel castings, as has been done, to receive the balance of the shock which the spring fails to absorb, serves primarily to preserve the spring buffer attachment, but merely transfers the shock to the machinery of the locomotive. This same conception seems to have been noted earlier in car work. Mr. Carney * once made a remark, at a meeting of the Western Railway Club, relative to this point, which I quote: "If part of the car fails, and is strengthened, that part ceases to break, but some other part that has been strong enough before commences to fail, and in that way we go from the knuckle pin on one end of the car to the knuckle pin on the other end."

Attempts to remedy defects.

Slack.

In the present designs the spring buffer brings with it a spacing or separation between engine and tender which the inadequacy of the spring turns into nothing better than slack, so-called. Without the space element, difference in momentum between engine and tender becomes impossible. Therefore, I would say, let us bend our energies to the institution of some method of adjustment and frequent inspection that will tend to reduce this space element or slack between engine and tender to its very lowest terms, thus permitting them to become essentially a unit as affecting stresses in the direction of tractive effort.

Case of reversion to rigid chafing blocks

One road in abandoning the spring buffer has settled upon the policy of installing heavy rigid chafing blocks, allowing the wear in the drawbar and pins to accumulate until the riding of the engine renders the condition intolerable, when the drawbar will be inspected and shortened. This is assumed to provide a safeguard against the breaking of drawbars, but it appears to involve too much of the human element to satisfactorily solve the problem. Some enginemen will endure a large amount of the abovementioned discomfort while the protest of the engine parts themselves comes too late to be of service.

Two possible solutions suggested.

M. C. B. coupler principle.

From personal observation and kindly suggestions offered by motive power officials, it occurs to me that there are two possible solutions of the buffer problem; namely (1) the institution between engine and tender of some form of coupler after the fashion of the M. C. B. vertical plane device, modified to adjust itself more comfortably to short curves in the track than might be possible with the present design. It was my earnest desire to put the coupler principle into being before this date, but unforeseen events and unusual stress of business have prevented this experiment. I wish, however, to commend this feature to your serious consideration with the trust that the coming year may bring to light some data of actual trial along these lines.

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* Discussion — Draft Rigging in Relation to whole cars.— Proceedings of Western Railway Club, May 20, 1902.

pplication of ie adjustable.

(2) The alternative suggested would be to revert to the first principle of the adjustable wedge in taking up the slack.

An illustration (Fig. 18) is provided which shows a common form of the adjustable chafing block now in use. When the parts are made of steel, no excessive trouble from the breakage is experienced if the slack is properly followed up. It will be noted that the rubbing surface is necessarily flat, and that the drawbar is consequently stretched on curves unless considerable initial slack is provided. Moreover there is a tendency to wear a depression opposite the tender chafing block, which becomes eccentric after an adjustment of the wedge. It would seem proper, therefore, to suggest the use of rigid chafing blocks with surfaces curved from the drawbar pinhole as a center, and to provide the adjustment by placing one of the pins in a sliding block, adjusted by wedges as shown in Fig. 19. Such slack, however slight, as may be considered the maximum allowable before an adjustment of the wedge should have a corresponding consideration in the strength of the drawbar.

ummary of ecommmendaons.

In want of any actual information as to the behavior, hopeful or otherwise, of an adaptation of M. C. B. coupler principle between engine and tender, I am disposed therefore to propose as a final recommendation this:

1. That the provision for buffing stresses take the best possible form of an adjustable wedge.

2. That the drawbars be straight, even at the expense of redesigning foot plates and tender front draw castings in new work and renewals.

3. That the drawbar pinholes be provided with ample bearing area.

4. That an elongated eye be provided at one end to prevent the bar from coming ever into compression.

5. That sufficient stock be provided at both ends to prolong the wear in the pinholes.

6. That 4,000 pounds be aimed at as the working stress with straight bars.

7. That the drawbar shall be of the best material, and that a limit shall be set to the repetition of welding a bar in repairs.

Finally, that a system of inspection of drawbars and related gear at stated frequent intervals be instituted and rigorously observed.

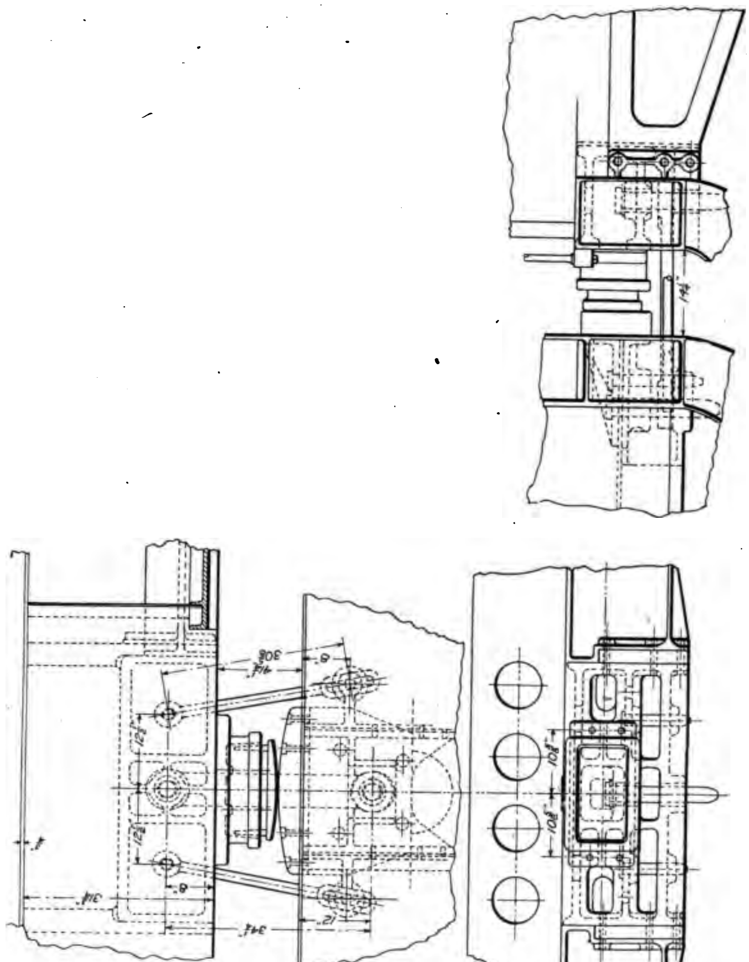


FIG. 5
DRAFT CONNECTION, PENNA. R. R.

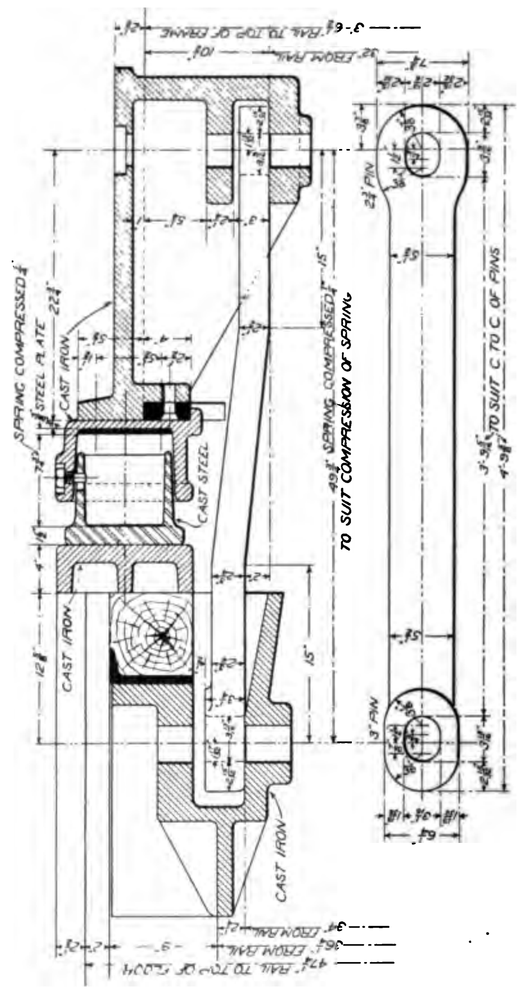


FIG. 6

DRAFT CONNECTION, SOUTHERN RY.

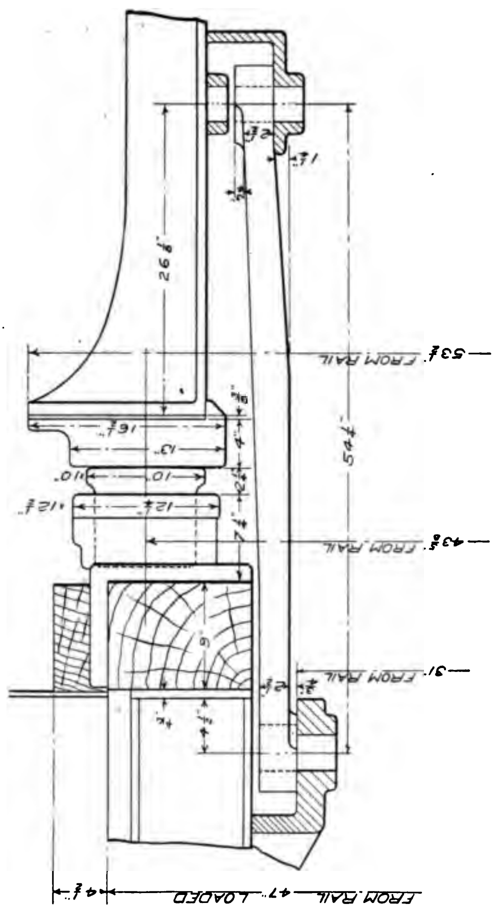


FIG. 7

DRAFT CONNECTION, N. Y. C. & H. R. R. R.

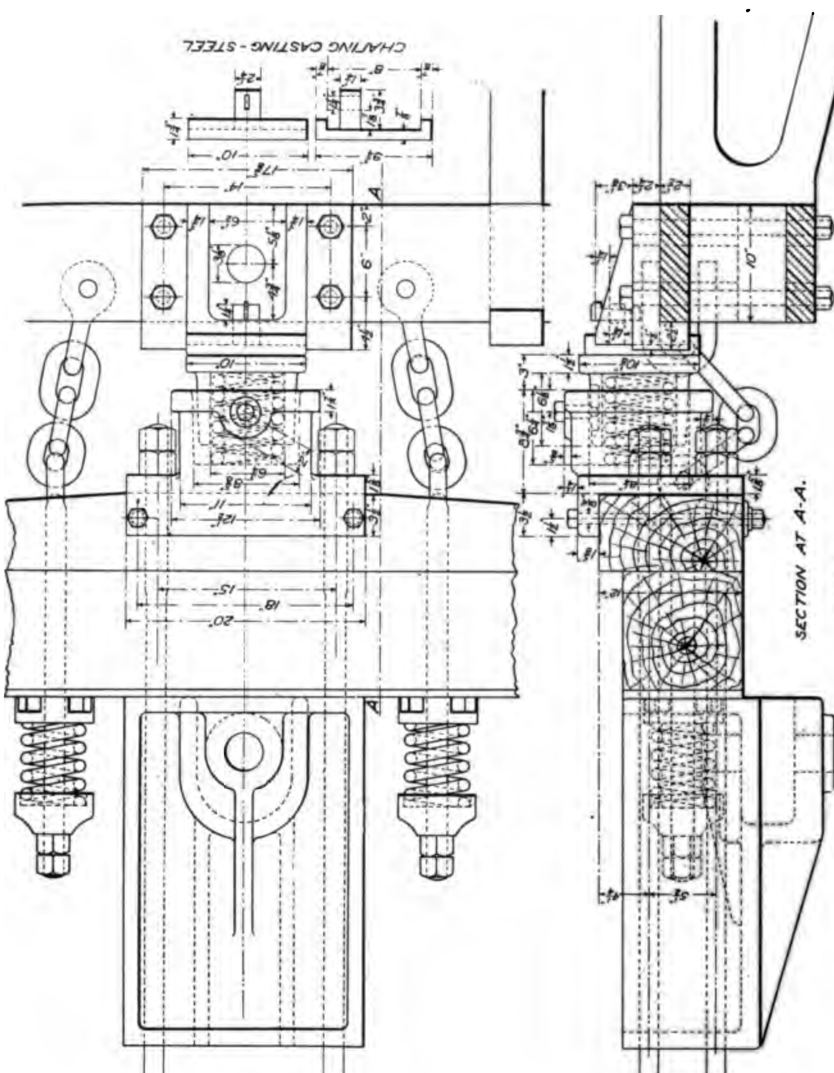


FIG. 8

DRAFT CONNECTION, N. Y., O. & W. R. R.

FIG. 10

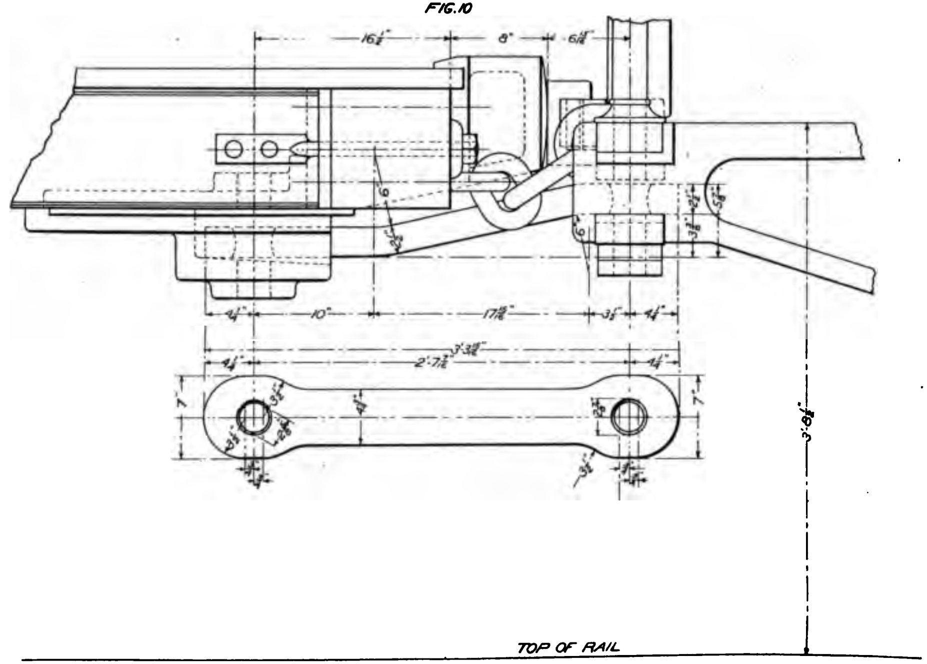


FIG. 9

DRAFT CONNECTION, N. & W. R. R.

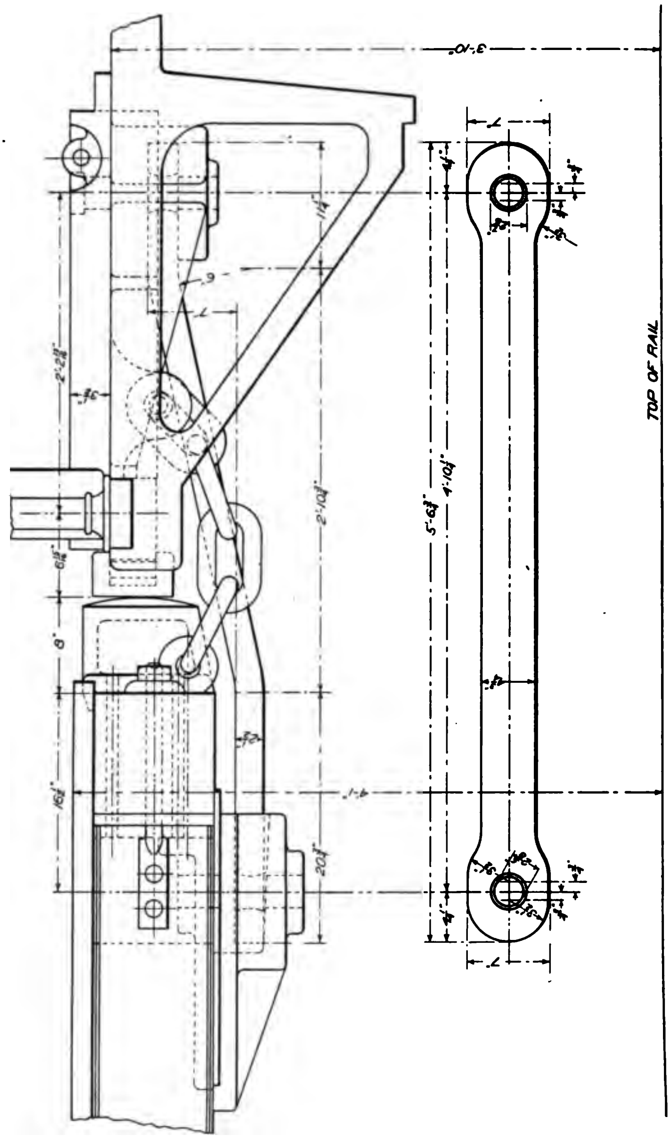


FIG. 10. DRAFT CONNECTION, T. & W. R. R.

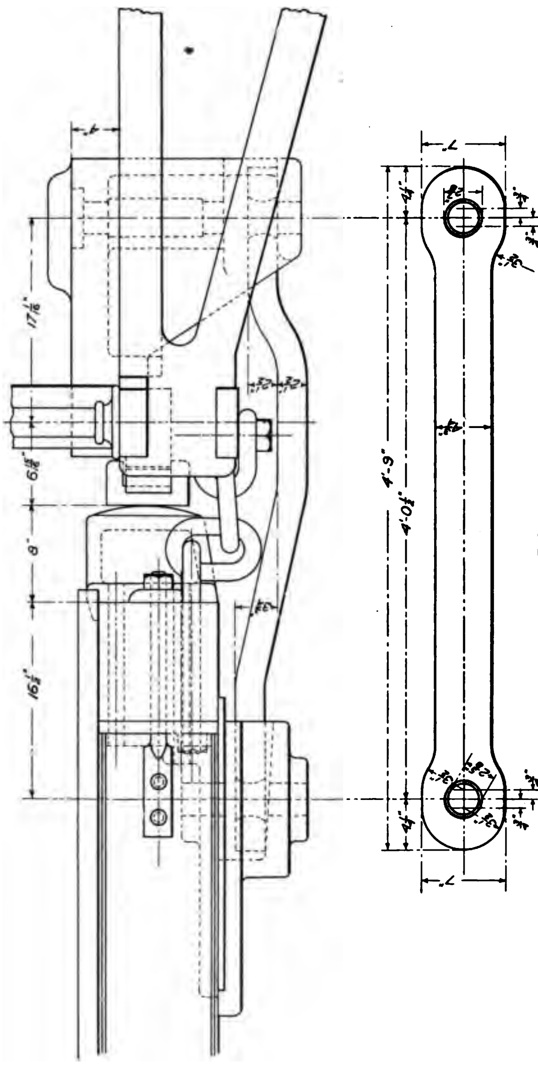
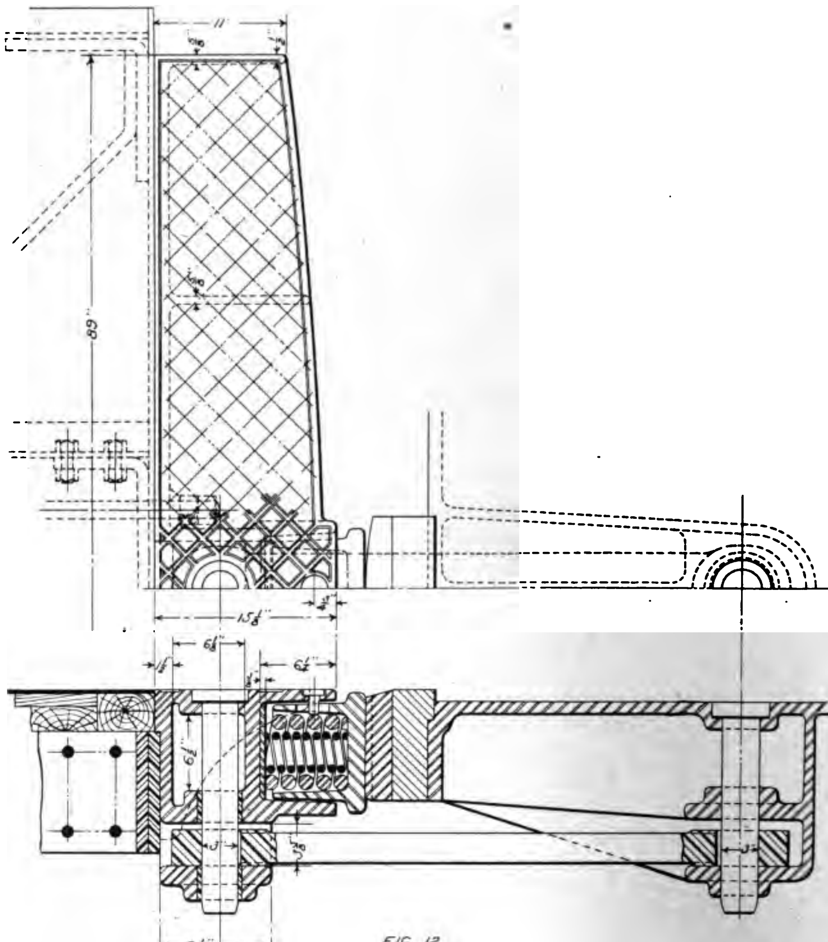


FIG. 11

DRAFT CONNECTION, SOUTHERN RY.



DRAFT CONNECTION, BOSTON & MAINE R. R.

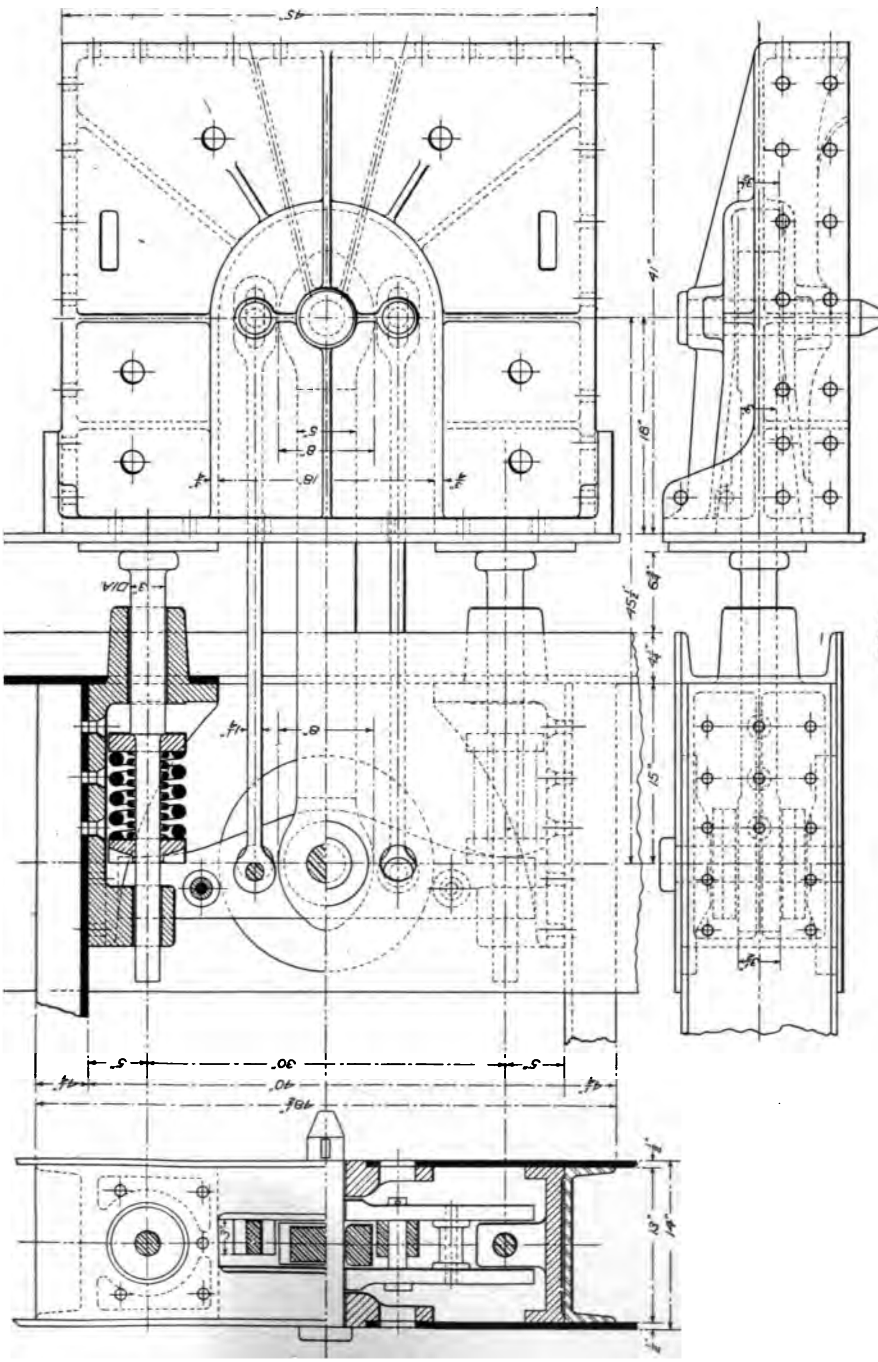


FIG. 13

DRAFT CONNECTION, EGYPTIAN RY., BROOKS LOCOMOTIVE WORKS.

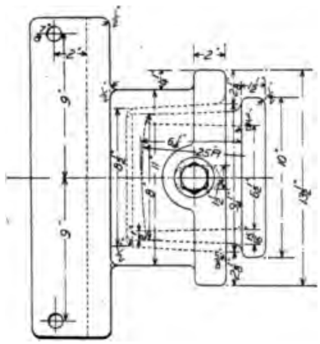
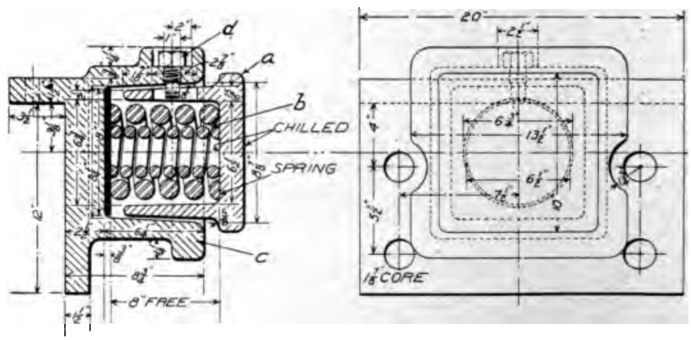


FIG. 14



SPRING BUFFER, USUAL DESIGN.

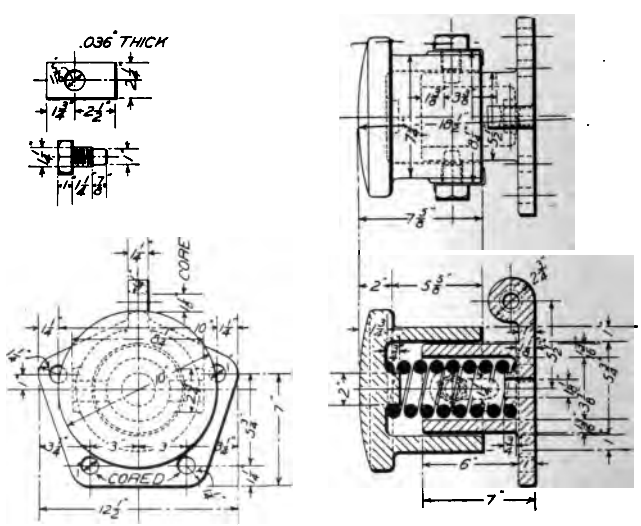
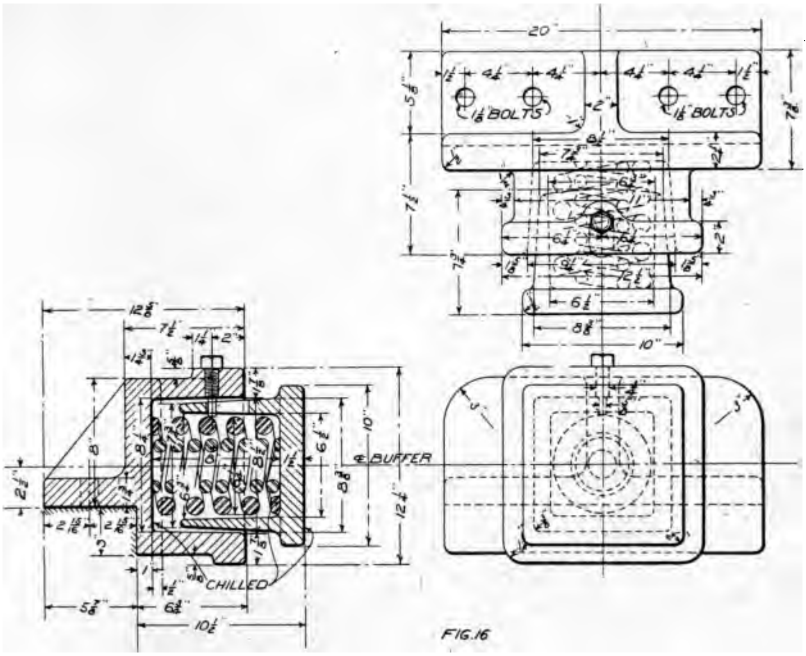
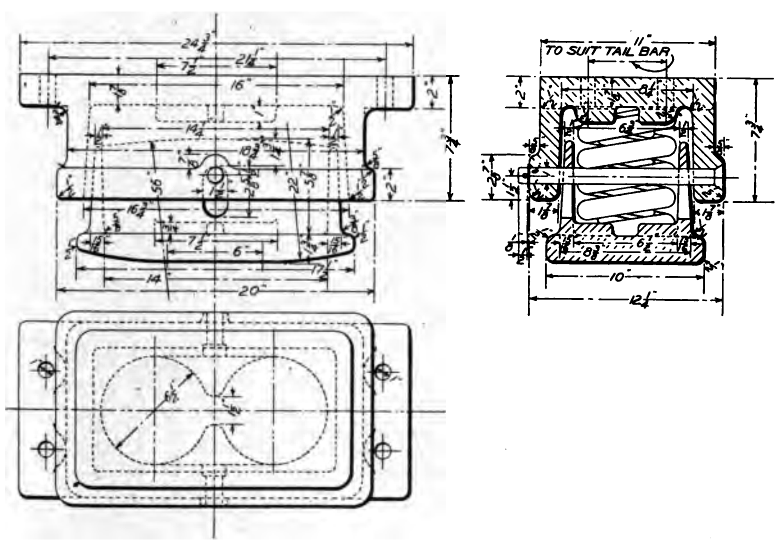


FIG. 15

SPRING BUFFER, N. Y., P. & N. RY.



SPRING BUFFER, SHOWING CENTER OF STRESS PASSING FAR ABOVE SUPPORT.



SPRING BUFFER, WITH DOUBLE TWIN SPRINGS.

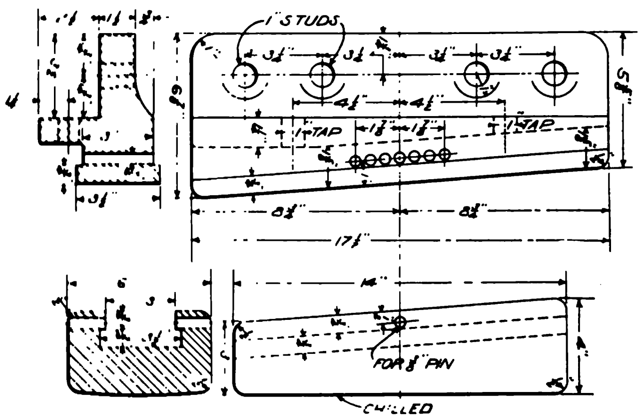


FIG 18

CHAFING CASTING, C. & O. RY.

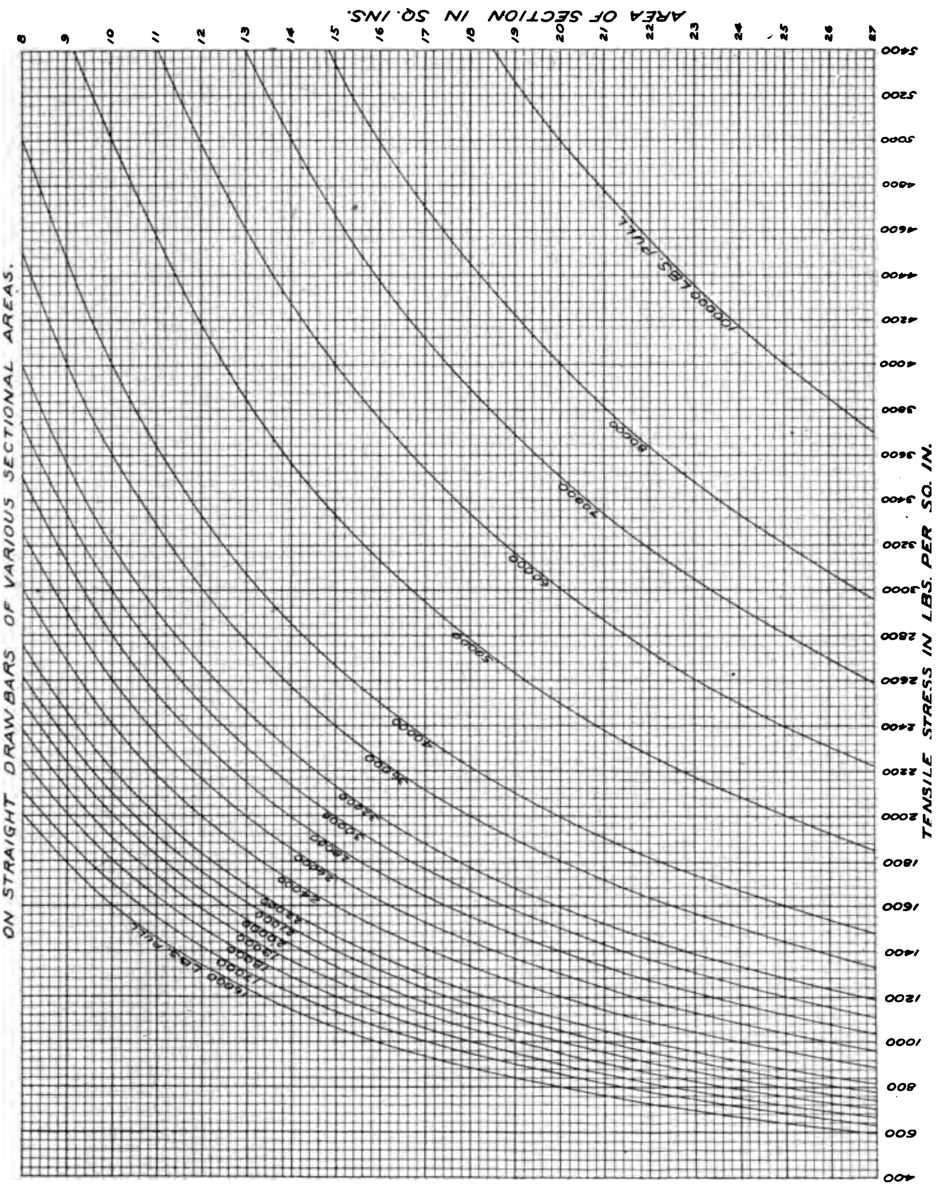


FIG. 20
TENSILE STRESS DUE TO VARIOUS PULLS
ON STRAIGHT DRAWBARS OF VARIOUS SECTIONAL AREAS.

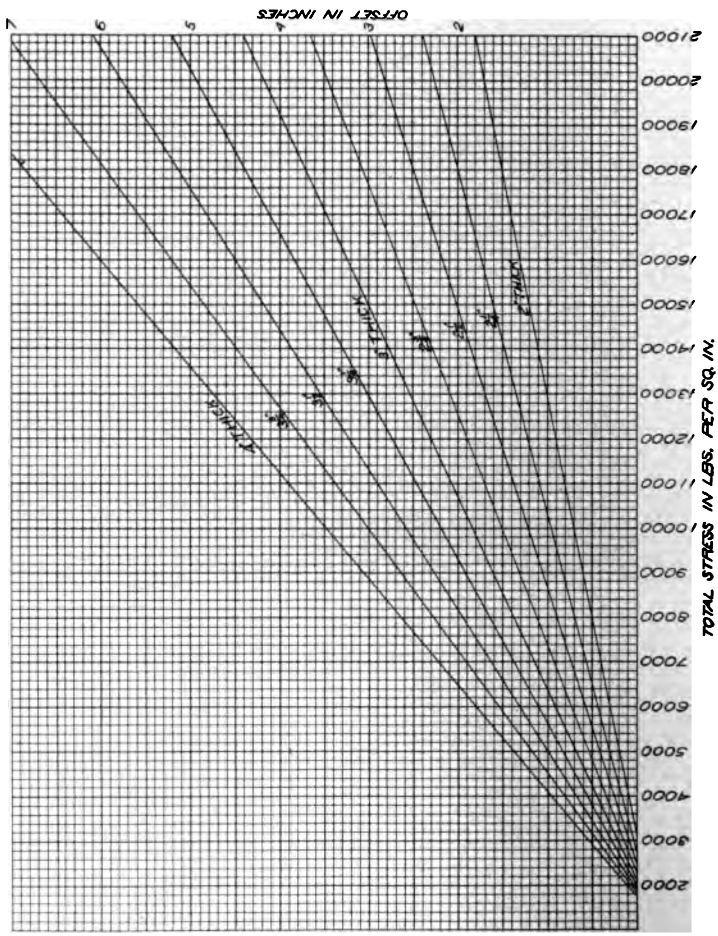


FIG. 21

TOTAL STRESS DUE TO PULL OF 32000 LBS. IN DRAWBARS 5" WIDE AND OF VARIOUS THICKNESSES AND OFFSETS

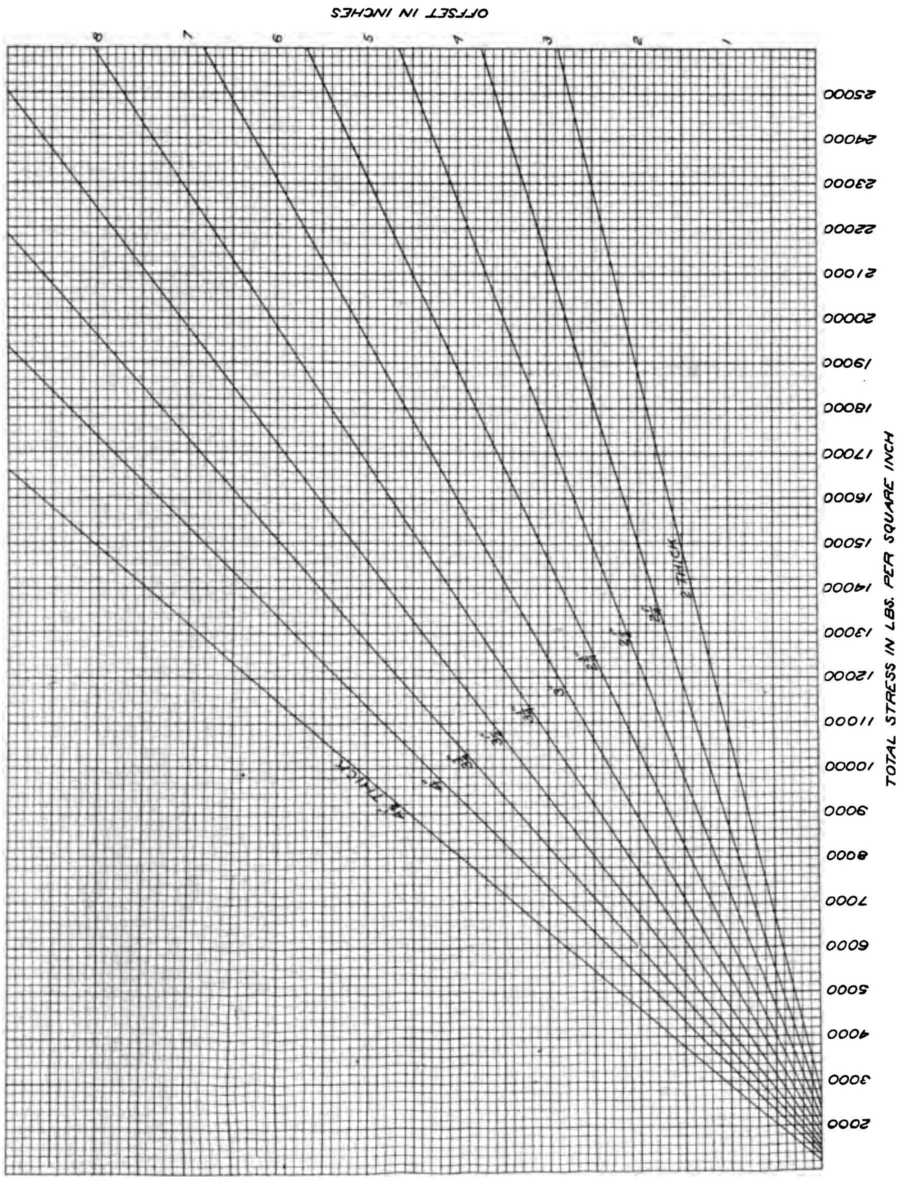
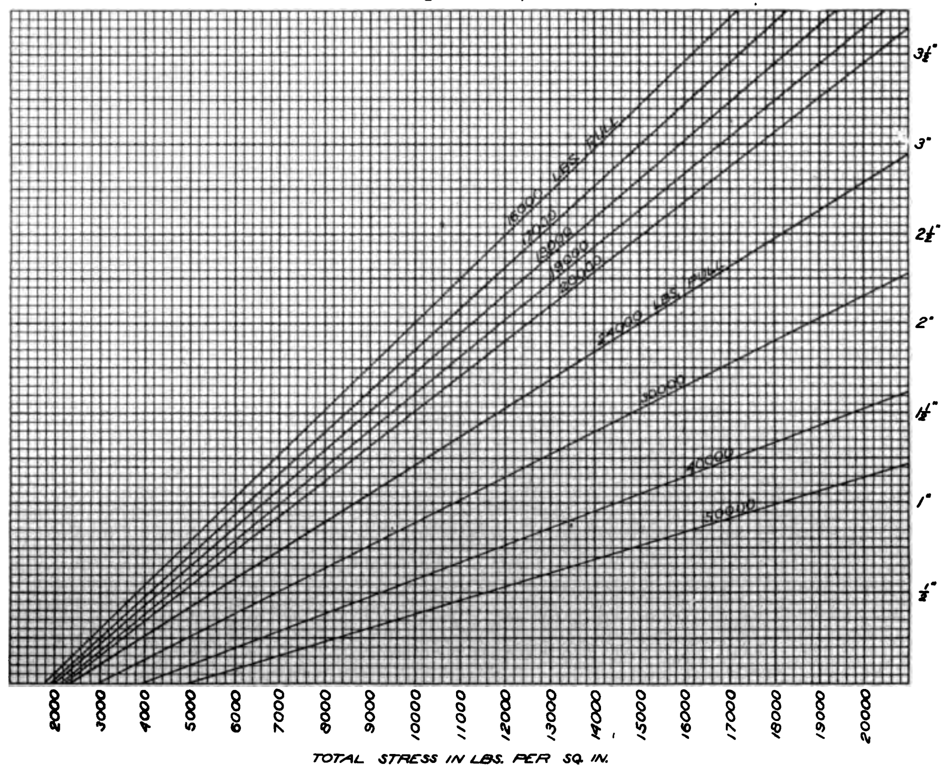


FIG. 22

TOTAL STRESS DUE TO PULL OF 32000 LBS. IN DRAWBARS 6" WIDE AND OF VARIOUS THICKNESSES AND OFFSETS

FIG. 23

TOTAL STRESS DUE TO VARIOUS PULLS AND OFFSETS IN A DRAWBAR WITH A SECTION $4\frac{1}{2}''$ WIDE X $2\frac{1}{4}''$ THICK



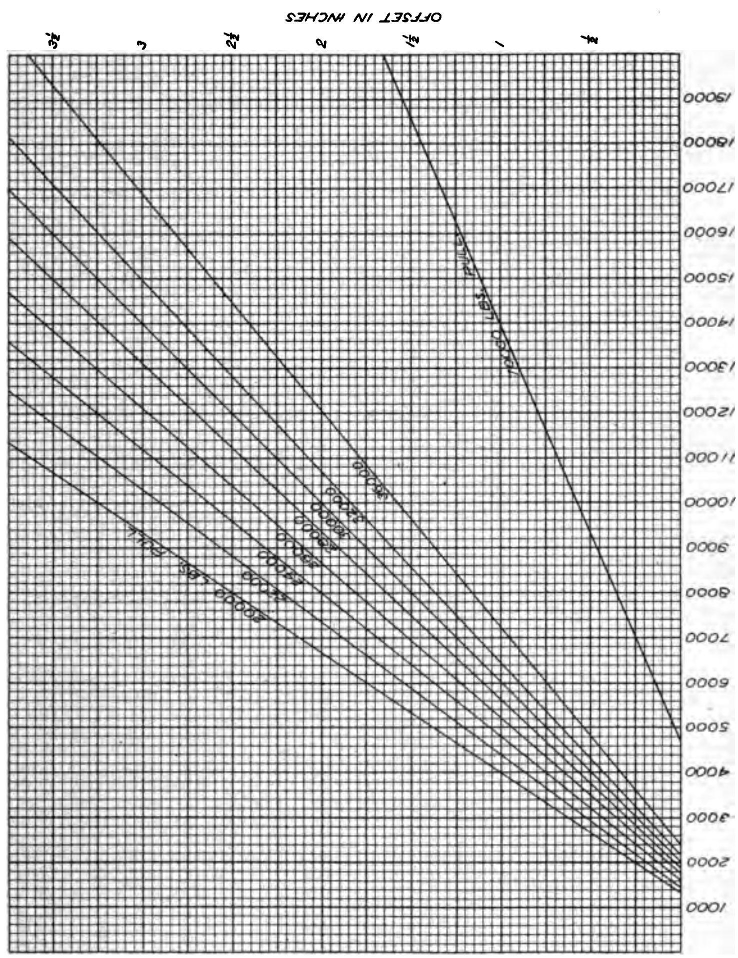


FIG. 24.

TOTAL STRESS DUE TO VARIOUS PULLS AND OFFSETS IN A DRAWBAR WITH A SECTION 5" WIDE X 3" THICK.

FIG. 25.

TOTAL STRESS DUE TO VARIOUS PULLS AND OFFSETS IN A DRAWBAR WITH A SECTION 6" WIDE X 4" THICK.

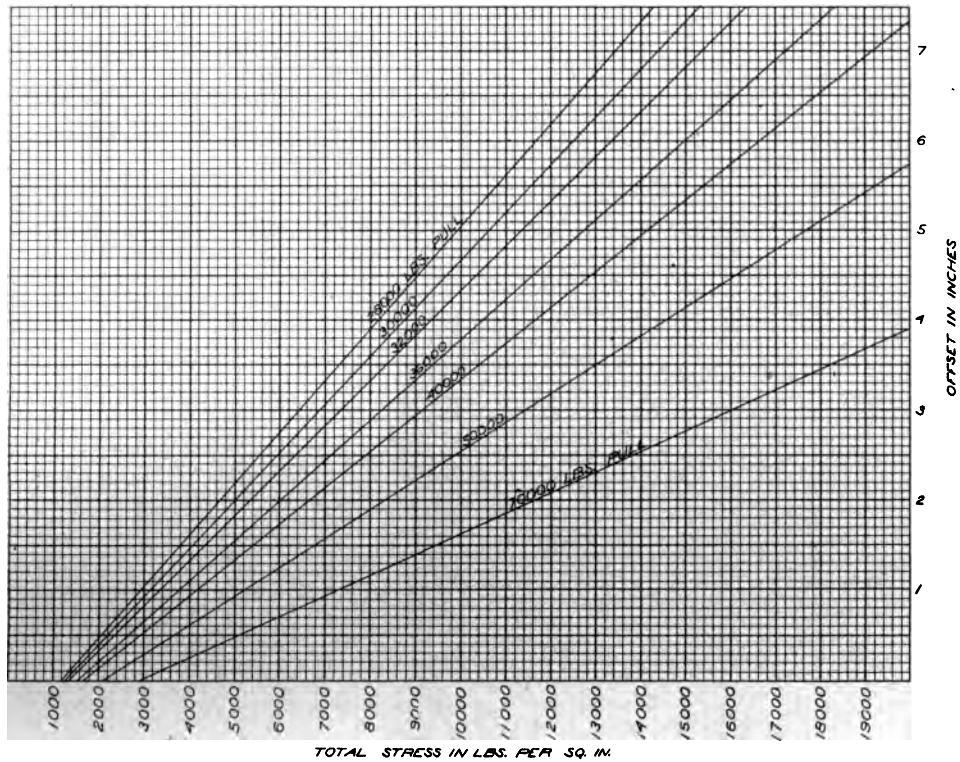
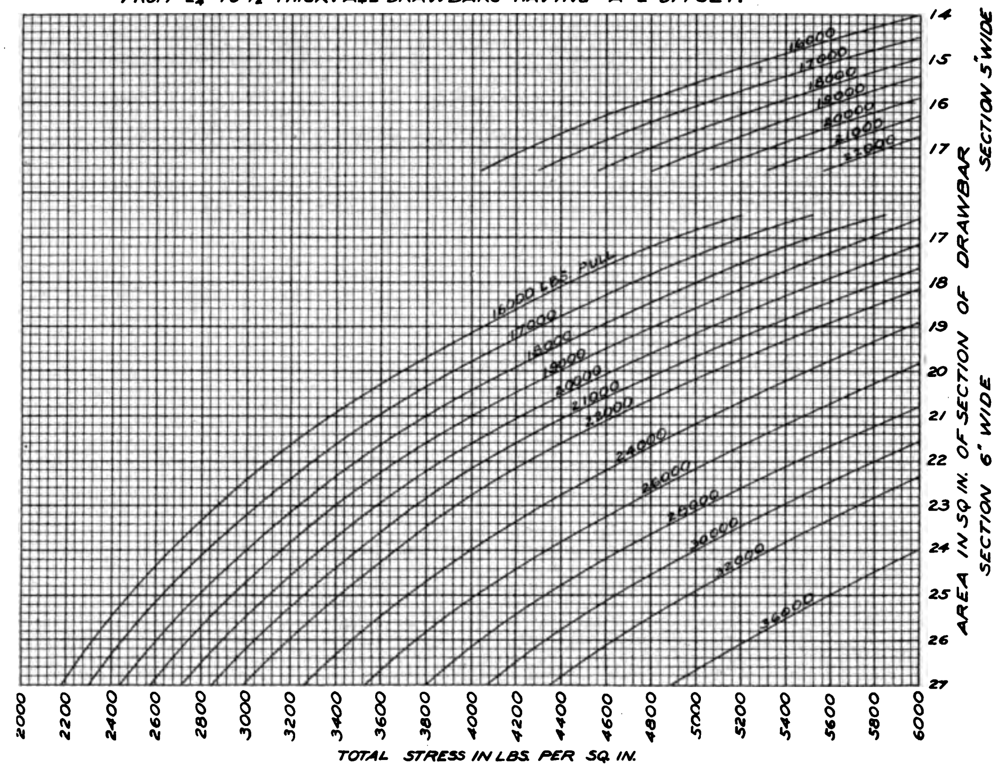


FIG. 26

TOTAL STRESS DUE TO VARIOUS PULLS ON DRAWBARS WITH SECTIONS 5" AND 6" WIDE, AND FROM 2¾" TO 4½" THICK: ALL DRAWBARS HAVING A 2" OFFSET.



THE PRESIDENT: The paper is before you and open for discussion.

MR. WILLIAM FORSYTH: Mr. Bartlett has just said that the spring-buffer arrangement is a failure, or, rather, that it has been so reported to him by a large road. In contrast with that, I was told recently by the mechanical engineer of a large road that the spring arrangement between engine and tender was the most satisfactory thing to use, and was a very successful arrangement on their engines.

These two opinions simply illustrate the difficulty there is in getting at the facts in questions of this kind. Mr. Bartlett, in the first part of his paper, shows the extent of the stresses between engine and tender, by referring to the report of the tests which were made of friction draft-gear, but it occurred to me that it was strange, after referring to these, that he did not suggest that the friction draft gear on the tender would be likely to produce a favorable effect on the draft gear between engine and tender. I think it will be interesting to get some opinions on that question, as to whether the friction draft gear has not reduced the wear and stress between engine and tender where it has been applied on the back end; and, further, if on large engines this matter of draft gear between engine and tender is such an important thing, why the friction draft gear should not be used there, and on both engine and tender?

MR. BARTLETT: In regard to the matter of the spring arrangement between the engine and tender, it seems to me the engine and the tender should be bound together as one unit. There should be no lost motion at all, and I could not see any better solution of the matter than the wedge arrangement proposed on page 16 of the paper. I do not see any necessity of a spring attachment between engine and tender, as it would seem an additional encumbrance. If the engine and tender can be bound together in one unit all the time I do not see why they should not be. I know there are some very strong opponents of the spring arrangement, those that have had considerable experience in heavy service, and they are very pronounced in the contention that there should not be any spring between the engine and tender; that there should be a positive tie, no lost motion, and that the strains and shocks,

which have become so great now, have proved difficult to overcome by the use of springs. I feel quite sure from my own experience that in heavy service, in due time, the spring buffer is going to tell its own story.

THE PRESIDENT: This is certainly an important matter. The fact that an engine breaks away from a tender, which a little lost motion frequently causes, is a very serious matter.

PROFESSOR HIBBARD: The only reason that I have ever seen for a spring connection between engine and tender was that when the engine and tender were on a curve, the drawbar would not get cramped and broken, and it seemed to me that the rigid wedge connection, if the wedge and buffer block are flat, causes the breaking of drawbars. With a drawbar 4 by 2 and made of decent hammered iron there is no tensile strain that would naturally come between the engine and tender sufficient to break it; but we know that they have broken, and it appeared to me that the only reason for the breakage was because the non-adjustable or the rigid wedge connection causes the drawbar to be elongated when you put engine and tender on a curve, so that if you would only put in enough lost motion there to provide for that cramping, it seems to me that is the only good of the spring. I note on page 10 of Mr. Bartlett's paper that he suggests rounding the buffer block so that it will not cramp the drawbar on a curve. I would like to inquire whether he expects that that rounded buffer will always stay round when well worn, and if it does wear flat after a few years and you set up the wedge to take up the lost motion, are you not going to have the same difficulty of breaking your drawbar by cramping it on curves?

MR. BARTLETT: I did not expect that the buffer would stay round all the time, but it can be renewed there by pieces on the face, whenever necessary, just as most of the buffer castings are now.

MR. DAVID BROWN: The report is so good and emphatic that there is very little to say about it. Each point is taken up very thoroughly and that is the reason we can not pick it to pieces. As regards the spring between the engine and tender, what we have had is of very little importance. There is so little of it that it blocks up right away, and, furthermore, as Mr. Bartlett says, if

the drawbar is not slotted to allow it to come solid to the chafing iron, if it touches the pin at all, no matter how big the pin is, you will break it. We have seen that illustrated by hard knocks that were hard to correct. When they had the impact, there was not sufficient play in the drawbars to take up the whole of the spring, and the consequence was the pin received the blow and it snapped off, which it will do every time. That is covered in the report very thoroughly.

As regards the shoe, it is very well for taking up lost motion. We do not expect that the chafing irons, even if coupled up tight when the drawbar is stretched, will remain so all the time. The trouble Mr. Hibbard spoke of does not take place except the first day or so after the engine is coupled up, as the bar and chafing plates are very near the center line. It is not the same as if there were two springs on it straddling this drawbar. Two springs, in some places, would interfere with drawbar, but where the chafing iron is over the bar there is very little required then to allow for curving. Whether or not the wedge is the best thing, I have my doubts. I think if we have a deep and broad solid surface, well hardened or chilled, it lasts quite a while. Otherwise you can not find the least fault with the report of the committee. Every point is taken up very thoroughly.

MR. J. L. LAWRENCE: One of the previous speakers spoke about the frictional draft gear being applied between the engine and tender, as well as the rear end of the tender. It seems to me that is a good suggestion and at present I see no real reason why that could not be applied there. I think it would result in beneficial service. As far as the wedge question is concerned, my experience has been that with the wedge casting and shoe we have a great deal of trouble with the tail piece of the engine getting bent. That is a piece of iron, probably on the average engine 2 by 7, and we have had them bent edgewise by the slack of the train coming in on them, with nothing to take it up. I also find that it is quite difficult to keep the wedge in its proper position, that is, to take up the slack of the drawbar, by putting the wedge in as it is necessary.

The spring buffer arrangement between engine and tender, in my opinion, is quite an improvement over the wedge arrangement. If you have your casting on the tender, which can be made of a

chilled casting sufficiently rounded, a well-designed draft spring in your buffer block on the engine, adding to that oblong holes in your draft iron, my experience has been that we have never had a single draft iron break on the engine using that device. I feel that the spring arrangement between engine and tender is the best we have in use to-day, unless, perhaps, the frictional draft arrangement may come up and supersede it. While it has never been brought to my attention before, on the spur of the moment I believe it is a good idea and worth a trial. I believe that it will give good results, but next to that I think the spring arrangement between engine and tender is better than the wedge arrangement.

MR. H. H. VAUGHAN: I would like to say a word in favor of the spring attachment as against any frictional draft-gear arrangement between engine and tender. I think the reason that something of this sort is advisable is on account of the continual movement of the engine under the action of the steam and the overbalance. When the engine has a little play between the friction plate and the wedge, there is a continual small movement of the engine to and from the tender. By putting a spring attachment, having a certain amount of initial tension, between those two, you are able to utilize the weight of the tender in steadying the engine, and I believe it is of advantage in that respect.

Referring to these forms of spring buffers, Fig. 16 and some of the previous figures, they show a spring buffer having a comparatively small surface, not over eight or ten inches, and in some cases having a rounded face. These spring buffers have given considerable trouble by cutting in, one into the other, even when the faces are pretty well chilled. We went through that experience and got up a buffer that is very similar to the one shown on Fig. 17, the double-spring buffer, with one exception — the spring buffer shown on 17 has a rounded face. I believe that is wrong. The effect of the rounded face will be that as the engine curves away from the tender, slightly, there will be a grinding action between the spring buffer and friction plate. We made that face straight and attempted to get the same action between the spring buffer and the friction plate that you obtain between the buffers on the vestibule cars, a purely sliding action. I think you could even go further and make the face of the buffer considerably

longer, obtaining an action just like the sliding action between the buffer plates on vestibules. You then get enough surface to keep the friction plate up and prevent the spring buffer from cutting into it and the angular movement is taken up by the rock of the buffer on the springs. That is the type we have adopted and it has given very good satisfaction and prevented the cutting in of the buffer on the friction plate and has allowed us to maintain a certain pressure on the spring to steady the engine and tender together.

MR. VAN ALSTYNE: I agree with Mr. Vaughan that the spring buffer is preferable to any other arrangement. In fact, I think that a spring buffer is necessary. I do not believe it is possible to put up a rig between engine and tender with solid wedges that will not wear very rapidly, for the reason the engine and tender are moving sidewise on each other constantly, and the rougher the track the more they move. But no spring buffer I have had anything to do with has had capacity enough. Another especial point in connection with spring buffers is that it is necessary to get a broad surface rather than a round surface that reduces the bearing area.

MR. C. H. QUEREAU: A road with which I was once connected had the wedge form of buffer or connection between the engine and tender for taking up slack, and it was very much abused by the men, and also a constant source of annoyance and expense. The men would frequently set the brakes on the tender, give the engine steam and pull the engine and tender as far apart as possible, and then jam the wedge in as far as they could get it. The wonder was that the wedge did not injure the drawbar seriously; and there were one or two cases in which I believe the cause of the breakage of the drawbar was from abuse of the wedge. The wear was very rapid on the wedge. It is entirely possible that the surface of the wedge was not as hard as it should have been. It was chilled, however. The wedge was frequently lost by the pins which held it in position — by which the slack in the wedge was adjusted — becoming loose or broken, and very frequently the wedge itself became broken. I realize this may have been due to defective design or defective material, and yet I was persuaded at the time that it was a poor design. I know the

engines, when this wedge was not up very tight, rode quite hard, maintaining a constant fore and aft motion, which made them difficult to ride. On account of these objections, on some new power which was bought we had the spring buffer put in between the engine and tender; but I was not connected with the road long enough after that to be able to give a final opinion on how that acted, but for a period of something over a year my conclusion was that the spring buffer was much more satisfactory. It was true that the bearing surface was not as broad as it might have been, but so far as the riding of the engine was concerned and the failure of the drawbars was concerned, the spring buffer was much the better design.

On motion of Mr. Angus Sinclair, duly seconded, the discussion was declared closed.

THE PRESIDENT: The Secretary will now read a communication from the Pennsylvania Railroad Company to the American Railway Master Mechanics' Association.

THE SECRETARY:

"PHILADELPHIA, PA., June 19, 1903.

"*To the American Railway Master Mechanics' Association:*

"The Pennsylvania Railroad system has arranged with the Universal Exposition of 1904, at St. Louis, to install as a portion of its exhibit in the Department of Transportation, a locomotive laboratory, to be built upon the most approved designs, and to be operated during the seven months of the exposition for testing locomotives.

"The entire exhibit, including the locomotive laboratory, will be in charge of Mr. F. D. Casanave, special agent, who is authorized to act for the Pennsylvania Railroad system in all matters pertaining thereto.

"It is the desire of the Pennsylvania Railroad system, as well as of the exposition, that the series of tests to be conducted shall be upon the highest scientific basis, and the effort will be made to obtain results which will be of permanent value. The details of the plan have not yet been fully perfected, but it is expected that a large number of the most recent designs of American and European locomotives will be carefully and thoroughly tested.

"In order that the best results possible may be attained, it has been decided to ask your honorable body and the American Society of Mechanical Engineers each to appoint an advisory committee of three members. The Pennsylvania Railroad system will provide all necessary apparatus and the force of engineers necessary to conduct the tests. It is desired that the advisory committee shall assist in laying out the program of tests and in making the plans that are necessary to secure the most important

and most reliable results. You are requested to appoint such a committee, and to appoint men who will be able and willing to give the necessary time and study to the subject. It is important that the plans should be effected at the earliest date possible in order to secure the hearty and full coöperation of the railroad companies and the locomotive builders, both in this country and in Europe.

"It is our intention to ask the general commissioners of the principal European countries to appoint, each, a mechanical engineer of high standing to represent those countries on the advisory committee.

"For the Pennsylvania Railroad system:

"J. J. Turner, Third Vice-President.

"Theo. N. Ely, Chief of Motive Power.

"For the Universal Exposition, St. Louis, 1904:

"Willard A. Smith, Chief Department of Transportation Exhibits."

MR. F. H. CLARK: Mr. President, I offer the following resolution:

"WHEREAS, This association has been informed by the Pennsylvania Railroad Company that it will erect at the World's Fair, St. Louis, 1904, a complete laboratory for the testing of locomotives, at which it contemplates making full tests of locomotives of various types, as well as of special appliances pertaining to locomotives; and

"WHEREAS, The Pennsylvania Railroad Company has invited this association to appoint three of its members to advise and consult in the carrying out of this project; be it

"*Resolved,* That the president of this association be authorized to appoint, after conference with the Pennsylvania Railroad Company, three members of this association to act as an advisory committee to the Pennsylvania Railroad Company in matters relating to the testing of locomotives at the laboratory which that company is to install in the Transportation Building of the Louisiana Purchase Exposition, St. Louis, during the seven months from May 1 to December 1, 1904; and be it further

"*Resolved,* That the thanks of this association be tendered to the Pennsylvania Railroad Company for giving the members of this association the opportunity of participating in the investigations outlined in the preceding resolutions."

THE PRESIDENT: This important matter is now open for discussion.

PROF. W. F. M. GOSS: This Association has for many years been interested in the matter of obtaining accurate data upon locomotives, and has on frequent occasions taken action looking to the securing of such data under the auspices of the Association. It appears, now that one of the great railway corporations of this

country proposes to do what the Association has desired to do for so many years, and to give the Association a part in that work, and it seems to me it is a very good and generous solution of a matter which has long interested our members, and I hope that the resolution will prevail.

The resolution was put to a vote and unanimously adopted.

THE PRESIDENT: The next business in order is the report of the committee on Electrically Driven Shops.

The paper is as follows:

REPORT OF COMMITTEE ON ELECTRICALLY DRIVEN SHOPS.

To the Members of the American Railway Master Mechanics' Association:

Your committee to present statistics and information in reference to electric drive for shops begs to submit the following report:

Owing to the scope of the subject it has been thought best to subdivide the report into three parts — first, general review; second, systems and methods; third, statistics and data derived therefrom.

GENERAL REVIEW.

The general subject of electric transmission of power was first treated in the association by a committee report in 1900. This report covered the ground so well that it should really be read in connection with this portion of our report, as our main endeavor will be to show how nearly the railway world has approximated that committee's conclusions and recommendations in the design of electric power installations in recent years. We quote from that report as follows: "Electricity is to be credited with ushering in a new era of labor-saving shop devices." Labor-saving seems to be the keynote in the development of most all recent shop plans. Central power plants with all the latest improvements in the way of coal and ash handling machinery, automatic stokers, direct connected generators and engines, the latter compounded and in some cases condensing, are almost the rule. These power houses are also very generally equipped with pumping plants for pumping air; for pumping water for various purposes including hydraulic power, boilers and general uses. Thus emanates from the central power station electricity for power and lighting, steam for heating and testing, air for power and special uses and water for power, general uses. and fire protection. Such concentration although apparently expensive in first cost permits of the greater economies in the production of the power as a whole, whether of steam, air, water or electricity. Once in the shop, the last named "mode of motion" easily leads in importance and proportionate use. Why? Simply because a charged wire is a more convenient agent for distribution of power than shafting and belting. The latter interferes with crane service, with placing

machines in the most convenient ways and places, and this all leads to the conclusion that the modern method is to study movement of material, utilization of labor-saving appliances in handling material, making the arrangement of the tools subservient thereto and in a way of secondary importance.

The one thing that has contributed most to economize movement of materials is probably the electric traveling crane, lifting a single part or perhaps a whole locomotive, carrying and traversing at desirable speeds over the area covered by the span and travel, hoisting and lowering at will great weights with slow, safe speeds and by auxiliary hoists doing rapid work with light weights.

If machine tools are set under a crane span, in most cases they require an individual drive and therein the electric motor proves its superiority as a medium for distribution and its adaptability as an important element of modern shop designs. One may say, if motors are such a good thing why not have all motors and no shafting at all. I quote a recent writer as follows:

"The individually applied motor is now accepted as an established feature in every machine shop. The period of careful investigation, followed by that of cautious probation, is passed, and this type of power application has now been in practical service sufficiently long enough to provide data that can be studied with profit. This data enables one to make more accurate deductions than were possible in the past, and enable those unfamiliar with the art to undertake its application with greater certainty of results."

This, however, is an extreme view and while it is practiced to a limited extent in railroad shops it is believed not to represent good judgment nor engineering. What necessity is there for crane service over small drill presses, small lathes and planers, screw machines, bolt cutters and many such machines? Most of the tools which should be under crane service require considerable power; such as wheel lathes, planers, boring mills and slotters, rolls, punches, shears and heavy engine lathes. The motors for these are large enough to have a good electrical efficiency and a relatively low cost per horse power as compared with the motors which would be required if the foregoing list of machinery was to be individually driven.

Sufficient belt power is often difficult to obtain to work modern tools to the capacity of some of the improved tool steels and it is much easier to directly gear a motor of suitable size to such machines and by a system of speed control drive the machine up closely to the endurance of the cutting tool.

The recommendation of the committee of 1900 in regard to variable speed motors and "that the attention of the electrical companies should be called to the importance of filling this requirement in their line of standard motors" seems to have borne fruit, as there are now on the market such motors capable of one hundred per cent speed variation, or two to one.

By employing the two voltages of a three-wire system a four to one variation is obtained; this, together with suitable gear changes in the machine, will provide for desirable speed variation of tools.

The same end may be obtained by the multiple voltage systems which have claims worthy of study and consideration.

The alternating current and induction motors were given favorable mention by your former committee and have been used to considerable extent in recent shop installations. While they have undoubted advantages in many ways and may by future development attain to the full field of usefulness of the direct current motors, yet the present state of the art has not qualified them for variable speed work so desirable for individual drive for machine tools. For crane service both direct and alternating motors are used, but the latter require special controlling devices and as yet are not extensively used.

Closely related to the question of power is that of lighting, and in many of the recent installations both power and light are taken from the same circuits, or at least from the same generators with perhaps separate light circuits. Both classes of current are used, the choice being governed generally by local conditions. The three-wire direct current lends itself well in this connection, as 110 volts is generally considered the best for lamps, both arc and incandescent. It also gives 220 volts for constant speed motors for group driving and other work where the class of motors are applicable, also for the crane motors, and both voltages for the variable speed motors for direct driving of individual tools.

It is impossible to say what is absolutely the best system, as no general rule can be laid down to cover the varied conditions, lay-outs and requirements met with in railway shops. The local conditions of ground, surroundings and requirements as well as the idiosyncracies of the designers of shops make every new one a problem by itself to be solved individually.

SYSTEMS AND METHODS.

The designer of a new railroad shop at the present time, in arranging for the generating station and power transmission, is primarily confronted with the problem of deciding which system of electrical power shall be used, the alternate or direct current. Each has its strong advocates, who can advance numerous points in favor of their preferred system, and the question is frequently complicated by local conditions to an extent which makes a decision extremely difficult. It may be necessary to combine in the power plant for the shop, a generating station for furnishing current for light or power to other company property, passenger depots, freight houses, car repair plants, and similar uses which are located at a considerable distance. For such purposes alternate current is recognized as being an economic necessity, the cost of copper required to transmit the energy by a low voltage, direct current system being practically prohibitive. In another instance the converse of this may be the case: in place of the power plant being required to transmit power to a distance or furnish

current for uses other than shop operation, it may receive its power from some outside source, in which case it becomes merely a transforming station to convert the current transmitted, which it may be assumed is a high potential alternating current, into a form suitable for distribution around the shops. In either case the conditions are identical in one respect: alternating current is necessarily used in the power plant; and in both cases also direct current can also be furnished for shop purposes if desired, either by the use of rotary transformers or motor generator, or, in the first instance, by the installation of direct current generators for shop use separate from those used for the long-distance transmission.

On the other hand, no long-distance problems may interfere with the choice of a system, the power plant may be entirely used for furnishing energy to a group of shop buildings sufficiently near together to make a low voltage reasonably economical, and whichever system is used is selected solely with reference to its presumed advantages for shop driving.

The above instances represent the effects of local conditions, and while they may be modified in the first examples by the proportion of the total power required for shop or outside purposes, there are evidently two possible general conditions to consider: First, where it is necessary that alternate current be present in the power house; second, where it is not necessarily present.

Now, whichever of these two conditions confronts the designer, there is one important fact which affects the problem in the present stage of the development of the alternate current motor, namely:

That if electrical speed control is desired, direct current must be used for driving those tools on which it is employed. Assuming, therefore, for the moment, that it is immaterial which system is used for the operation of cranes, transfer tables and driving machinery in groups or constant speed tools, the really important question to be decided is whether or not electrical speed control in some form or other is desirable. A number of articles on this subject have been written, and they are all worthy of careful perusal and study, but the main question is whether the extra investment necessary is justified by the results obtained. There is no doubt that practically all those connected with shops in which some form of electrical speed control has been installed will speak very favorably with respect to its convenience and the economies resulting from its use, but it certainly entails an extra expense and it is necessary to demonstrate that the benefits received are sufficient to outweigh the additional cost. Usually the possible economies are alone referred to, but a preferable method is to find what increase in output is necessary to compensate for the investment and then discuss whether it may be confidently anticipated that this increase will be obtained. This method of reasoning, which is equally as sound as the other, will be found to fit the case considerably better. It is difficult to obtain figures from which the additional cost of electrical speed control can be definitely determined, and no attempt has been made to obtain them from the various members of this association, although it

would be most valuable if they could be furnished in an intelligent form for the proper discussion of this question. For this report the cost figures of the Collinwood shop of the L. S. & M. S. Ry., in which the Crocker-Wheeler multiple voltage system is employed, have been carefully analyzed, and while the results are not accurately applicable to other shops in which the number and character of the tools may vary, and the method of speed control be different, yet remembering that the larger tools in all locomotive shops have a fairly close similarity and that the tools of each description are employed in about the same proportion, it is fair to assume that, while there would be a variation, it would not be important in the gross result and this assumption will be confirmed by an inspection of the figures.

To ascertain what percentage of increased output must be obtained to justify the application of electrical speed control it is first necessary to formulate the factors that determine the cost per annum of operating a tool. These are as follows:

1. The direct labor charge per diem.

2. The indirect labor charge, including what are generally known as shop expenses, superintendence, power, lighting, etc.

3. Interest and depreciation charge on the cost of the tool.

4. Interest and depreciation charge on the proportion of cost of machine shop and power plant, including generators, etc.

5. Interest and depreciation charge on switchboard, balancers, wiring, motors and controllers, etc.

Of these factors the only one affected by the use of electrical speed control is No. 5, the others being independent of it. The value of them has been estimated for the locomotive shop at Collinwood from the actual figures of the cost of construction as follows:

1. The direct labor for three hundred days at $2.80 per diem is $840 per annum.

2. The indirect labor charge may be taken at twenty per cent. This figure is fairly representative of railroad shop practice.

3. Interest may be taken at five per cent, depreciation at ten per cent. This figure may be considered high, but if rate of depreciation is lowered, it makes less output necessary to earn the investment on the installation of speed control and it is desired to be on the safe side. At Collinwood there were thirty-eight tools equipped with M. V. control, total cost $89,644.34, an average of $2,360 per tool. Fifteen per cent of this sum is $354, the annual charge per tool for this item.

4. The proportionate cost of the building that can be charged against any tool is more or less of a guess; but it is a real charge without question. At Collinwood, where locomotive erecting machine shop and boiler shop are under one roof, and the only figures available are the total costs of the entire building, the fairest way is to find the cost per cubic foot of shop and thus determine the cost of the machine shop itself, dividing this among the various tools in proportion to their cost. This is not exactly correct, but as the more expensive a tool is, the more floor space it occupies

and the more room is required around it, this method is as fair as possible, and on this basis the cost of shop, including buildings, heating and lighting apparatus (outside of power plant), cranes, etc., is equal to $1.03 per $1 cost of tool. The proportionate cost of power plant is fairly arrived at by dividing the cost of the plant by the horse power of output, and charging this against the tools in proportion to their consumption. At Collinwood the total cost per horse power of output is $86, and as the actual consumption of the M. V. tools is 70 horse power, the amount invested for their operation is $6,020, or $158.50 per tool. The total investment under this heading is, therefore, $2,430 plus $158.50 per tool. On this amount interest may be charged at five per cent and depreciation at six per cent, the life being longer than for tools, the total annual charge per tool thus being $284.73, say $284.

5. This item is separated from No. 4 as it includes all charges that vary according to the system of control employed. It includes numerous small items as follows:

(a) Proportionate part of cost of switchboard and 220-volt feeders in ratio of horse power consumption of M. V. tools to total, $1,226.

(b) Prorated cost of M. V. portion of switchboard, M. V. transformer and inside feeders in proportion of M. V. tools in machine shop to total, $2,821.

(c) Cost of wiring M. V. tools. This is not by any means an easy figure to determine, but has been estimated very closely by obtaining the total cost of labor and material for wiring all tools in locomotive shop, exclusive of the feeders to the distribution boxes, and dividing the labor by the number of tools wired and the material by the horse power of tools wired. To allow for M. V. tools, each of them is counted as two tools wired and as being of double the rated horse power. In this cost there was also included the power wiring in each erecting pit, each pit considered as representing one tool of five horse power, which is very closely correct. The result of this calculation is that it cost $4.80 per horse power for wiring material, $18.30 per unit tool for wiring labor.

As there were thirty-eight M. V. tools with a total rated horse power of 270, these amounts are as follows:

38 tools wired at $36.60	$1,380.80
270 x 2 horse power at $4.80	2,592.00
	$3,972.80

(d) The cost of motors actually used on the tools including controllers, etc., $12,150.

The total cost of item No. 5 is, therefore:

(a)	$ 1,226.00
(b)	2,821.00
(c)	3,972.80
(d)	12,150.00
	$20,169.80

This amount is considered to be subject to five per cent interest and ten per cent depreciation as in the case of the tools themselves, the annual charge thus being $3,025.50, or $79.70 per tool.

Recapitulating the above the average annual cost for operating thirty-eight multiple voltage tools based on the Collinwood construction accounts would be:

Item 1	$ 840.00
Item 2	168.00
Item 3	354.00
Item 4	284.00
Item 5	79.70
	$1,725.70

Now, if multiple voltage had not been employed the only change in the cost of the plant would have been in item 5; the subdivision costs would become as follows:

(a) There would be no change, it remains		$ 1,226.00
(b) This cost is avoided without corresponding charge.		
(c) This cost becomes:		
38 tools at $18.30	$ 690.00	
270 horse power at $4.80	1.296.00	
		1,986.00
(d) The cost of motors required on the various tools including starting boxes		7.200.00
Total		$10,412.00

Fifteen per cent of this amount is $1,561.80 or $41.10 per tool per annum.

The total annual cost of operating a tool is thus $1,725.70 with electrical speed control, against $1,687.10 when driven by constant speed motors, or an increase of 2.24 per cent. In other words it is only necessary to obtain an increased output of 2¼ per cent to justify the extra expense.

There is little doubt that any one who has been connected with a shop in which some such system has been employed would hesitate for a moment in stating that a saving is obtained many times that required to equal the additional cost, to say nothing of the increase in output, but there are objections to the method usually employed in giving the reasons for this economy which is based on the assumption that the production of a tool is proportional to the cutting speed of the work. It is true that in the average belt-driven tool the various changes of speed usually vary by increments from forty to fifty per cent, but it does not follow that the work performed need vary in any such ratio. In any given material with the same cutting tool, which is being operated to its capacity, the amount of metal that is removed in a given time depends on three fac-

tors — the cutting speed, the feed and the cut. These factors are not independent, but with a given feed and cut the tool will stand up satisfactorily at a certain speed, with a different feed and cut the maximum practical cutting speed will vary, and so on. The law connecting these three factors is not yet properly determined, and will probably vary for different materials. This much, however, can be stated, that for medium steel, such as that used for driving axles, crank pins, etc., the amount of metal that can be removed per minute with the same depth of cut and with feeds varying from 1-8 to 1-20, the speed in each case being adjusted to the limit of the tool, does not vary fifteen per cent. This may not be the case so closely with other materials, but it is certain that a variation in the feed affects the permissible cutting speed in every case, and within the limits of a speed variation of forty per cent it is possible to so adjust the feeds and cuts so that the amount of metal removed per minute is substantially the same. It might be stated, therefore, that, theoretically, it is unnecessary to have small and easily made variations in speed, but there is another and more important side to this question, the practical one of how to get as nearly as possible the maximum product from a tool. If a machine were employed steadily upon work in which the material were of uniform hardness, and the dimensions of the pieces the same, it would probably be possible to get the same output when the speeds vary by forty per cent steps as when they vary by ten per cent by the adjustment of the feeds and cuts, but even assuming this to be exactly true, it is a condition that does not obtain in the majority of machine shops, and is practically absent in railroad shops. While machines may be classified as to the work they perform, this work varies quite a little in its dimensions on account of the various forms and sizes of the parts used on different classes of engines, and the materials employed are also subject to considerable variation in their cutting qualities. How is the output determined in such a case? With a belt-driven tool the machinist sets his feed at what he considers is right and runs his tool at a certain speed. He may try the next speed higher, which is an increase of say forty per cent and finds it is too high. The result will be that he returns to the original speed and the work proceeds at that rate. It might be possible to use a larger feed but it is very liable not to be done, and indeed outside of a few lathes, feed cnanges can not be made rapidly and easily and in many tools are too coarse to be effective. The speed change, when made by belt cones, takes a certain amount of trouble and is very likely not made as often as advisable. In general, it is difficult to adjust an ordinary belt-driven tool to the best cutting conditions, and it may be taken at the best to run as nearly as the cones allow, say within twenty to twenty-five per cent of the maximum on the average. Compare this with a tool having electrical speed control. The work is being cut at a certain speed; by the movement of a lever placed conveniently to his hand, the machinist can increase the speed by from ten to twenty per cent up to the point at which it is found possible to run. There is no exertion involved, no time

wasted, and, in fact, there was no real excuse for not operating the tool at its proper speed. If the work has two or more diameters, it is a matter of a second or so to change to the suitable speed. If the material is harder than usual the speed reduction is simply that necessary to meet the condition and not twenty-five or very like forty per cent more, as may easily be the case on a belt-driven tool. There the man will not be found to shift the belt whenever a change is necessary, and he can hardly be expected to do so; with electrical control the change is so easily made that he should and can be expected to attend to it. With reasonable encouragement and intelligent control it is fair in this case to assume that on the average the machines can be run within ten to fifteen per cent of the possible speed, giving an increased output theoretically of at least ten per cent and in practical working a great deal more, from the closeness of the speed control alone, to say nothing of the saving of time in the manipulation of the machine resulting from this system. On wheel lathes, there is a special advantage, that when one or two hard spots occur in a tire, the machine can be slowed over these spots and the speed restored for the balance of the circumference; this feature is not very important to the shop as a whole, but it is quite important on that particular tool.

Another advantage of speed control is the opportunity it affords for a practical system for setting cutting speeds. As above mentioned this is for any material dependent on the feed and cut, but in the majority of cases in locomotive shops the variation in cut on similar classes of work is not important. Now, by adopting a uniform feed for all roughing work or two uniform feeds, one for heavy and one for light work, the most important variable is eliminated and the speed proposition becomes comparatively simple in place of being exceedingly complicated. The depth of cut is of minor importance within the limits in which it usually varies and by standardizing the feeds it becomes possible to estimate very closely what speed should be employed on different materials and obtaining a satisfactory output is correspondingly feasible. In such a system it is obvious that the ratio of the actual to the possible product depends on the closeness with which the speed can be regulated, and as a difference of ten or fifteen per cent in the speed is sufficient to ruin a tool in a few minutes or allow it to run for an hour or more it is evident that it should be controlled by at least that variation.

In general it may be stated that while close electrical speed regulation may not be theoretically necessary, it presents a practical method of increasing the output from shop machinery that can not be approached by the old belt and cone pulley, and that this increase in output should largely outweigh the slight additional cost, and in any shop where this small increase in outlay can be made in order to effect a substantial economy in operation, in other words in any shop that is laid out on reasonable business principles, some form of speed control should be applied.

If this proposition is assented to, the use of direct current to a greater or less extent follows as a matter of necessity in the present state of the

electrical art, for no contractor is yet prepared to figure on A. C. variable speed apparatus, and the point next necessary to determine is the extent to which it is advisable to apply this principle. The factor affecting this chiefly is the extent to which it is commercially advisable to direct-connect tools. If it were decided to direct-connect all tools, an inspection of the figures above presented will show that the limiting factor affecting the application of speed control is not the size of the tool, it is the wages of the operator; the smaller the tool and the less the horse power required to drive it, the less is the additional expense of applying electrical speed control and there is consequently but little difference in the increase in output required to compensate for the additional investment. On a tool costing $500 and requiring three horse power to drive it, the items calculated as above are as follows:

Item No.	With Speed Control.	Without Speed Control.
1	$ 840.00	$ 840.00
2	168.00	168.00
3	75.00	75.00
4	66.00	66.00
5	69.00	34.50
Total	$1,218.00	$1,183.50

a difference of $34.50 or 2.8 per cent.

The wages of the operator are thus the most important factor, as if, in the case of this tool, they were decreased to one-third the amount the increase in output required would become 5.2 per cent; even at that figure, however, the difference would render the question one of the type of tool and general convenience, and the extent to which direct-connection is advisable is thus the most important. At Collinwood tools were direct-connected for three reasons:

1. Where they were located under cranes to allow of their being placed in the most convenient positions and to avoid countershaft supports interfering with the crane service.

2. On tools above three horse power where the advantages of speed control were considered sufficient to justify it.

3. Where tools were in isolated positions and expense of line and countershafting would exceed cost of applying motors.

The remainder of the tools in the machine shop, 103 in all, are group-driven, and the cost of installing these tools has been analyzed to show how it compares with the cost direct-connected on one assumption, namely: that no additional price would be demanded by the builders in supplying their tools with suitable attachments.

The 103 tools are driven in eleven groups, the total tool horse power being 242.5; to drive these tools the group motors have a total of 202.5 horse power, which is larger perhaps than necessary but was considered advisable.

The cost of the driving arrangement was as follows:

Eleven group motors	$ 4,550.00
Wiring eleven motors at $18.30	191.30
Wiring 202 ½ horse power at $4.80	972.00
Countershaft supports, line shafts, pulleys, etc.	6,667.00
Belting	3,881.00
	$16,261.30

Had these tools been direct-driven cost would have been as follows:

One hundred and three motors	$12,340.00
Wiring 103 tools at $18.30	1,884.90
Wiring 242 ½ horse power at $5.40	1,164.00
	$15,388.90

This result may appear surprising, but it is even more favorable to the direct-driven estimate than it appears. The roof construction must be appreciably heavier when it is expected to support countershafting than would be the case if simply required to cover the building. Additional members must be incorporated, but this expense we are not in a position to estimate at present. Then no charge is made against belt-driven tools for belt shifters and the cost of applying the belting, which for 103 tools is quite an expense. It would be interesting to obtain figures on the cost of maintenance of belting in this connection. The cost at Air Line Junction shop, a woodworking plant on the L. S. & M. S., has been obtained and found to be twenty-five per cent per annum for material alone. This expense would certainly be less in a machine shop, but can be safely estimated to be equal to the increased amount of repairs to the motors. To enable these figures to be fairly understood it should be stated that at Collinwood the countershaft supports are 6-inch channels, bolted together by separators and bolted to the under side of the roof structure, which was arranged to permit of this without drilling any holes for bolts or other fastenings. The structure on the whole is, therefore, not expensive, and if a cheaper form of support had been adopted the influence in the total cost would not have been sufficient to make belt connection the cheaper. These costs it must also be understood refer to a machine shop, where the tools are closely placed and group-driving appears in its most favorable light. In a wood mill or boiler shop, where tools are widely placed, a very rough estimate will show the economy of direct-connection, as in such a case it is far cheaper, to say nothing of the saving in power by not running long and heavy line shafts to drive a few tools intermittently.

The whole question is up to the machine tool builders. If they can furnish tools which can be direct-driven for the same price as when belt-driven, which is largely a question of preparing their designs to meet the demand, then it will cost no more to direct-drive tools than it does to belt-connect them in groups, and when this can be said the advantages of indi-

vidual driving will make this practice preferable. It is not necessary at this time to go over the many desirable features of this system of power distribution, the flexibility it allows in shop arrangement, the absence of belts and overhead line and counter-shafting, and other economical advantages will certainly lead to the use of direct-connection unless the cost is prohibitive, and it would certainly appear from the above discussion that with the adaptation of machine tools, the introduction of suitable designs, not only will this not be the case, but that the converse will be true. While it is at this time impossible to make that statement, yet it can be said that direct driving should certainly be employed so far as it is not rendered prohibitive by the cost of motor application, and it would then follow from the earlier portion of this report that electrical speed control should also be largely employed.

There are at present in use a number of different systems of electrical speed control, all of which are probably satisfactory in operation. They have had in the past one decided feature by which they might be classified, the extent to which it was thought necessary to vary the speed of the motor, some systems employing a speed variation of 1 to 2 or 4, others a decidedly larger range of from 1 to 5 or 8. The question is one of the size of motor desirable to employ to drive any given tool and is thus partly commercial, the larger motor required for a wide speed variation being of course more expensive, and partly one of convenience, the smaller range systems requiring addition gear trains on many tools which can be avoided by increasing the speed variation of the motor, and conversely the large motors are inconvenient to apply and occupy valuable room in the shop. It may be safely stated that this question is being gradually settled as experience is developed and that a range of 1 to 3 or 4 will be very generally agreed on as the largest it is advisable to obtain by electrical means.

This range is being now obtained under two distinct systems, one in which three wres are used, giving voltages in the ratio of 1 to 2, the other, in which four wires are used, giving voltages in about the ratio of 1, 1⅓, 1⅔, 2. It would be possible of course to obtain three combinations of voltages by the use of three wires, but there would be but little advantage in this unless a greater speed range than 4 to 1 is required and so need not be considered. In both these systems intermediate speed between those at which the motor runs under normal conditions at the various voltages is obtained by the use of field and armature resistance, the difference between them thus becoming the extent to which this form of control is employed. There is, however, a considerable difference between the results obtained by field and armature regulation; the former does not affect the speed-maintaining qualities of the motor, and the extent to which it is advisable to use it depends in its effect on the commutation and internal losses of the motor. Armature regulation, on the other hand, depends on its stability on a uniform load being carried by the motor, a condition that does not obtain in machine tool driving. If sufficient resistance is introduced into the armature circuit to reduce the speed twenty

per cent at full load, the speed will be but slightly reduced at no load, while if the motor is working at one hundred per cent overload, as it may easily be doing for short periods, the speed will be reduced approximately forty per cent in place of twenty per cent. Such a condition is frequently found in practice and it is doubtful whether regulation of speed by armature resistance should be allowed to a greater extent than eight or ten per cent on account of this action. This does not apply to motors operating cranes or similar machinery, and on account of this action by which the voltage across the motor terminals is reduced when any heavy loads are taken, the use of a certain amount of armature resistance may be recommended on planers and other tools in which a large amount of power is taken at the instant of reverse. On a test of a 42 by 42 inch planer, at the Collinwood shops, it was found that the introduction of resistance equal to twenty volts at full load reduced the current taken at the instant of reversing fifty per cent, without seriously affecting the speed during the cutting stroke. As this class of tools is the one giving most trouble when direct-driven, it would appear advisable in all cases to insert a small amount of resistance in the current to obtain this action. In general, however, the above remarks hold good, and a variation of ten per cent is the limit to which this class of regulation should be used, or the speeds obtained by it will not be reliable.

On the 3-wire system it is therefore necessary to obtain the speeds intermediate between those obtained from the direct voltages, by field regulation up to a point that is within ten per cent of the higher voltage speed, or, in other words, a speed variation of eighty per cent must be obtained in this way. This was previously thought impossible, the maximum practical increase in this method having been assumed to be about thirty to forty per cent. During the past year or so, motors have, however, been developed that allow of this amount of regulation and with this improvement the 3-wire system becomes a serious rival to the 4-wire. These motors, which are special, are stated to develop a constant horse power over a range of one hundred per cent, so that commencing, for instance, at a speed of 250 revolutions per minute at 110 volts, the speed is increased by field weakening, up to 500 revolutions per minute. The speed with normal field at 220 volts is also 500 revolutions per minute, so that by running at that voltage the field can again be weakened until a speed of 1,000 revolutions per minute is obtained. To illustrate these conditions the diagram Fig. 1 has been prepared, on which is shown in full lines the horse power developed by such a motor at a varying number of revolutions. To make a comparison with the motor used on a 4-wire system having the same range 4 to 1, the same speeds and the same minimum horse power, the dotted lines on this diagram give the same information for that case, in which 40 per cent variation in speed is obtained by field weakening. This does not represent the practice actually recommended by the manufacturers, but is what would be furnished to obtain the same range and number of revolutions. This diagram shows up several points. First,

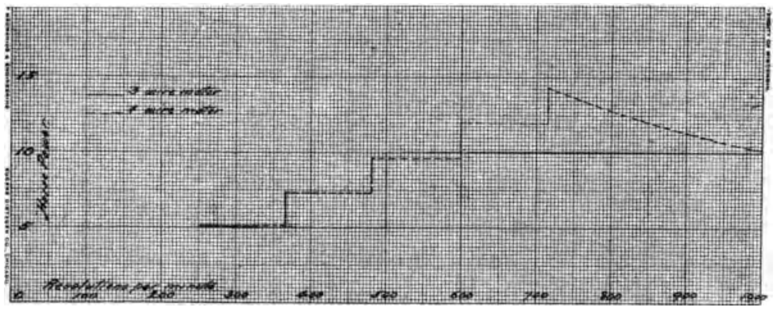


FIG. I.

that the same general size of motor is required by both systems to do the same work, since evidently in this case each requires a motor that will develop ten horse power at 500 revolutions per minute, although the 4-wire motor is capable of developing more at a greater speed which the 3-wire is not. It is fairly accurate to say, however, that the size of motor depends on the horse power developed at a given speed so that in this respect both systems are uniform. One point in this connection is worthy of notice. The 3-wire motor develops ten horse power at 500 revolutions per minute. At that speed it will also develop five horse power working on the lower voltage. Now, under the latter condition the current is the same, the speed the same, and the field is weakened fifty per cent. This is a condition under which the commutation would be equivalent to a motor working under one hundred per cent overload with normal field, if the motor were of ordinary construction. Your committee does not wish to go into the technical questions involved in this fact, but would call attention to it, as it is important. There are two factors affecting the horse power that can be developed by any given motor, the heating and the commutation. The latter is the condition that on ordinary motors first gives trouble. If then it is intended to install a 3-wire system with this method of speed control, special attention should be given to the capacity of the motor for commutation when working with weak fields, especially when overloaded under those conditions. It certainly requires a motor specially designed for this work, and it would not appear possible to adapt a standard motor to it.

Secondly, this diagram shows that while the 3-wire system gives apparently equal results to the 4-wire on tools requiring constant horse power, it is inferior to it on tools in which the horse power varies with the speed, such as, for instance, planers, slotters, shapers, etc. As these tools are not, however, in a majority, this feature is not perhaps of sufficient importance to seriously influence the question.

Again the 4-wire system affords, under the majority of conditions, greater power from the same sized motor than does the 3-wire. If the

motor is large enough under all conditions this is not important, but in a great many cases it will be found that unless motors are all installed that are of ample size, which means a relatively expensive plant, all the power that you can get out of a motor is a good thing to have and this feature must be taken as an advantage in favor of the 4-wire system. On the whole this discussion is rather in favor of the latter, but there are some other points on the side of the 3-wire that should not be overlooked. While requiring specially designed motors in place of the standard motors that are used on the 4-wire system, it is possible to so arrange the generators that the plant is independent of the operation of a balancing set. This would be a very considerable advantage, as, while a balancing set gives no trouble whatever in operation, if any accident should happen to it all tools dependent on the intermediate voltages for their operation would be put out of service, and in a large plant it would appear desirable to install it in duplicate. The 3-wire system also simplifies the lighting problem to a certain extent and affords what is practically a 3-wire system for that purpose. Your committee in general feels that on this subject the time is not ripe for any definite statement; the two systems referred to are both coming into use and their merits will be decided on the field of service. The chief features on one side and the other appear to be, the use of a special motor and one extra wire on the one side as against a standard motor and two extra wires on the other. There does not seem to be any great advantage in cost on one side or the other so far as investigation of the regular prices can determine where the cost of wiring is considered, and apart from this question, which is, perhaps, the most important one in the long run, the points deserving careful attention in considering the design of a plant would be the equal capacity of the motors offered for standing overloads so far as both heating and commutation are concerned, the speed of the motors at the maximum, which for equivalent cost it is desirable to keep equally low, the controller employed, the latter being quite an important detail of the apparatus, and the elimination of armature regulation beyond the limits referred to.

Beyond this discussion as to the system to be adopted for machine-shop driving which is decided by the above considerations, your committee does not feel that it desires to open the question of direct versus alternate current for purposes in which speed control is not required, believing that since technical discussions on this subject before societies of electrical engineers do not appear to have ever been productive of any definite results, it is hardly worth while approaching from the standpoint of those who are not electricians, and would leave it to the question of convenience and local conditions by which it is so strongly affected after the driving of the locomotive machine shop has been disposed of.

STATISTICS AND DATA.

The efforts of the committee to compile complete and full data has been frustrated by the lack of exact information, although every possible

effort to obtain same has been made, but it is hoped that before the paper goes into the Proceedings in permanent shape, any errors due to insufficient data will be corrected. Five or six shops are in process of erection at the present time while three or four others are in a preliminary stage; consequently none of these could be included in the table. It has been the endeavor of the committee to ascertain the "load factor" of the different schemes, but this could be obtained in a few cases only owing to insufficient data. By load factor is meant the relation between the capacity of generators (after deducting the constant or fan loads, the average lighting load, etc.,) and the variable loads such as shop tools. The figures obtained seem to show that if 40 per cent of the aggregate horse power of the tools is taken and to this are added the constant and the average lighting load, we have a figure which will represent the generator capacity required without the necessity of taking into the account the cranes transfer or time tables. In this connection a spare unit should receive consideration.

C. A. SELEY, Chairman,
H. H. VAUGHAN,
T. S. LLOYD,
T. W. DEMAREST,
L. R. POMEROY,
Committee.

CHICAGO, ILLINOIS, June 1, 1903.

MR. C. A. SELEY: The work of preparing this report has been very great, and the committee feels that a little stronger support would have given us the information desired as fully explained in this last section.

THE PRESIDENT: It might seem to be out of order for the President to order these papers received and opened for discussion without a formal motion. It is quite a waste of time to go through that form and, unless objection is made, each paper, when read, will be declared open for discussion. That will be the order of business hereafter. The subject is open for discussion.

MR. C. A. SELEY: This is a matter which I think is of very great importance, in view of the large number of new shops which necessarily have to be constructed throughout the country at large to take care of the vast, growing locomotive equipment of the country, and to properly and adequately handle locomotives of the power and weights which have now become standard. There is no question in the minds of those who have gone into the matter that electricity is a most useful servant in this respect.

In regard to a choice between the system which is perhaps most favorably spokén of in the second section of the paper, that of the four-wire, as against the three-wire, I have been brought to a more favorable consideration of the three-wire system, for reasons of simplicity and direct application to the principal uses for which electricity is required in shops. The 220-volt current is applicable for cranes, constant speed motors, fan motors and motors around the shop generally, where no speed variation is required. The 110-volt current is directly applicable for lights, and I think my argument will be granted by any one who has tried 220 volts for arc lighting. I regard the practice of putting two 110-volt arcs in series as a makeshift. The 110-volt arc lamp is far superior in the light which it gives to the 220-volt. The latter will give a blue flame and not the character of light, so far as I have been able to find out, that is comparable at all in efficiency to the 110-volt light. For incandescent lights, the 100 volts will give vastly better service than the 220 volts. The expression used in this second section in regard to the lighting is that there is a "certain" advantage in this respect. If I had written that portion of the paper myself, I should have emphasized it a little stronger. The second portion of the paper lays considerable stress on the possibility of not getting commutation of the motors with one hundred per cent field variation. I think we can obtain very authoritative evidence on this point that is comparatively new, and that it is a mark of progress in the art. I believe that it is perfectly feasible; in fact, I have gone to the extent of anticipating it as a fact, in a new shop installation, where I expect to put motors on individually driven tools, requiring speed variation, and get a clean four to one variation in the motor by the use of the three-wire system. That will require a ten horse-power motor on a tool requiring five horse-power to drive it. This system gives a practically constant horse-power throughout the one hundred per cent field regulation. Taking the diagram which is shown in this paper on page 14, the motor is shown with the three-wire system, as having ten horse-power at 220 volts at a normal speed of 500 revolutions per minute. Weakening the field up to one hundred per cent will give 1,000 revolutions per minute and still maintain ten horse-power. Intermediate points, by using the controller, can be had so that speeds between 500 and 1,000 revolutions can be obtained by the adjust-

ment of the controller. If, now, we shift to 110 volts, by switch arrangement, we have a five horse-power motor running at 250 revolutions per minute. We can again weaken the field on this voltage and maintain a constant five horse-power up to 500 revolutions per minute, where we again meet the normal rating of the motor, and can then have our ten horse-power if we wish it. This seems to be a system devoid of complications; it seems to be simplicity itself. You have all heard of the man who wanted a locomotive made in one piece, and I think that simplicity in electrical science can be cultivated to advantage as well as in any other branch of science.

MR. R. H. SOULE: I have no shops driven by electricity, but there are a few points in this paper I would like to speak of. Very early in the paper, speaking of power plants, it says that in some cases condensing engines are used. Among the power plants that I am familiar with, or have seen descriptions of, I have never found but one where condensing engines are used. That is the new power plant of the Chicago, Milwaukee & St. Paul road, at West Milwaukee; and if there are others, I would be glad to have them mentioned. This is a very interesting feature, a new feature, which has crept into railroad practice. Further on the committee says, in reference to cranes, that in some cases a whole locomotive is lifted. In that connection it is interesting to note that we have a shop recently illustrated, that of the Great Northern Ry. at St. Paul, a brand-new shop, where the cross-section shows absolutely no cranes whatever in the erecting shop. The engines are brought in by transfer tables and apparently they are treated entirely by jacks. That, also, is a very interesting phenomenon in the development of the art of railroad shops. At West Albany, on the New York Central road, they have a new erecting shop in process of construction, and as I understand it, although they have cranes there, instead of having one crane of 120 tons capacity to lift the complete engine, which is the usual practice in transverse shops, they propose to use two 60-ton cranes and to bring the two cranes up one on each side of the engine and sling the engines to the two cranes and move the engines in that way. This is also a very interesting development, because it seems to show a difference of opinion on what most people supposed was a

settled point, namely, that in a modern transverse shop you must necessarily have a 120-ton crane to lift the engine complete. Here you have a case of a new shop where that is discarded and two 60-ton cranes used instead of one 120-ton crane.

Later on the report asks, "What necessity is there for crane service over small drill presses, small lathes and planers, screw machines, bolt cutters and many such machines?" That perhaps refers to the Reading shops and the McKee's Rock shop, where the traveling crane service extends over the entire machine-shop floor, and it is natural that this arrangment should challenge criticism, as it is an unusual arrangement and will be watched with interest to see if they continue to think that it is a good thing or not.

After speaking of the cost of the new plant at Collinwood as being $86 per horse-power of output, it is not distinctly stated whether the $86 covers the whole plant, including the building, or relates only to the contents of the building, and it would be interesting to have that point brought out and commented upon.

Speaking of the load factor, the report says, "We have a figure which will represent the generator capacity required without the necessity of taking into account the cranes, transfer tables or turntables." Now, that seems to be a very remarkable thing, that you can afford to estimate for the generator capacity of the plant without any reference to your cranes, transfer tables or turntables. Since we have arrived at this meeting, most of us have seen in the technical papers that have been distributed here a plan and cross-section of the proposed new Lehigh Valley locomotive repair shop at Sayre, Pennsylvania, and as I remember, there are eight traveling cranes in that cross-section, beginning with two 120-ton cranes, and having, I think, six 15-ton cranes. Is it possible, in estimating the generator capacity of the power plant to drive these shops, that the eight cranes can be disregarded, and that you can estimate the capacity of the generators simply on the horse-power of the motors used to drive tools, together with the fan load and lighting load? It seems doubtful whether the proposed rule would give correct results in both of the extreme cases cited, namely, St. Paul, where there are no cranes, and Sayre, where there are eight.

MR. L. R. POMEROY: In the absence of a representative of the Great Northern Ry., I would rise to say a word by way of explanation relative to the Great Northern shops. For reasons entirely beyond the control of the designers, it was impossible to use a crane over the engine pits. A crane is provided over the heavy tool section, however, and one over the tracks or bays in the boiler-shop. The unwheeling of the engines is taken care of by a drop table operated electrically, and to make up for the deficiency of the crane for handling the small parts in the erecting of an engine, a system of electrical shop cranes is provided, one between each pit at the front end of the locomotive, which will handle everything down to the sand box. At the back end an electric walking crane is contemplated that will handle all parts at the back end up to the sand box, including cabs. That is the method they propose to utilize, as I understand it, to get around the lack of the large cranes.

Relative to the point that Mr. Soule made as to ignoring the crane loads — he lost sight of one fact, I think, which is stated in the paper, namely, the horse-power of the motors is ignored entirely and the aggregate horse-power of the tools used; of this a certain percentage is taken, to which are added the fan loads, and the crane loads ignored. Under such conditions I would use from forty-five to fifty per cent of the aggregate horse-power of the tools, but if an allowance for the cranes is added to the tool loads, the percentage would only be about twenty-five to thirty per cent of the total load.

I desire to say, further, that the report rather reflects the conservative opinions of the committee based on knowledge within the scope of their experience, and is, from the nature of things, conservative. In discussing the report, I feel it entirely within the province of the individual members to amplify some of the statements made, and to this end I desire to say a word concerning variable speed in tool driving obtained by field control. As the chairman of the committee has stated to you, the three-wire system necessitates a motor with a one hundred per cent field control. The opinion seems to prevail that speed control obtained by field manipulation is not legitimate and rather in the nature of a make-shift. I desire to go on record as stating that varying the speed

of a motor by means of field manipulation is commercially feasible, and mechanically and electrically practicable, and, further, that it is the handiest and simplest method of obtaining such variation. First, the horse-power remains constant, as the field strength is a function of the speed, while the current from the line across the armature is practically a constant quantity and the horse-power will vary as the voltage. As the horse-power required to remove metal is independent of the speed, the same horse-power is required at the lower speed as at the higher, and the speed regulation should vary as the diameter of the work, to obtain the same cutting speed throughout. Assuming for a basis a certain piece of six inches in diameter and that the spindle speed would be in the neighborhood of thirty-two revolutions, on a basis of twenty-four inches in diameter, in the same ratio, the spindle would make only eight revolutions a minute, and yet the same horse-power has to be maintained throughout.

Speaking of standard and special motors, as mentioned by other speakers, of course, there was a time when every motor was special — not a long time ago the induction motor was special. Relative to this motor, i. e., a motor constructed for one hundred per cent field regulation, it was constructed to make it practicable and feasible to use with such a range of speed. We call this motor " standard " because it is fully developed and on the market. Other people are selling it, and if a specification requires a speed regulation of four to one on a three-wire, or two to one on a two-wire circuit, any one seeking such a motor will get bids from any first-class manufacturer. One interesting point has developed in some experiments made since the paper was written, relative to the behavior of these motors, and that is, the motor will stand a very much higher overload capacity at the lowest speed than at the high speed. If the overload capacity at the weakest field is in the neighborhood of twenty-five per cent, at the lowest speed it is somewhere near one hundred per cent.

Right on this point there is an interesting article in *Engineering,* of June 5, as the result of a test on the other side, at Messrs. Vickers Sons and Maxim Works, conducted by Mr. A. D. Williamson. In this article it is stated that " The problem of varying the speed of motors without loss of efficiency has received a good

deal of attention during the last few years, and there is now no difficulty in building motors with a range of three to one, or even more, on a two-wire circuit, by varying the field excitation. The limiting factor is the highest speed to which it is permissible to go from mechanical considerations. A three to one range appears to be about the most economical one for motors of fair size, say from 250 to 750 revolutions, or 300 to 900 revolutions for motors from five to thirty horse-power. Any reduction of speed below about 300 causes the weight and price to rise rapidly." I would call your attention to the fact that they are getting three to one on two wires, not on three wires. We were speaking of only two to one on two wires, and four to one on three wires. The article referred to continues: " An application of variable speed motors which the author believes to be novel, has been recently used in the electrical manufacturing shop of Messrs. Vickers. A portable vertical planer or slotting machine is driven by a five-brake horse-power motor with a range of speed from 300 to 900, the motor being attached direct to the machine. On the cutting stroke the motor runs at its slowest speed, and at the end of the stroke, the length of which is easily adjusted to suit the work, the motor reverses automatically. As soon as the reversal has occurred, a resistance is automatically inserted in the field winding, quickly raising the speed to 900 for the return stroke. At the end of the quick-return stroke, immediately before reversal, the field resistance is short-circuited, providing a strong field for reversing in, and the motor reverses and makes its slow-cutting stroke, the cycle repeating itself." The article also states that this is done without any tendency toward sparking on the commutator. Surely such manipulation will be admitted as being very severe, and demonstrates quite clearly the speaker's point, that field regulation is legitimate and practical from an engineering standpoint.

THE PRESIDENT: We would be pleased to hear from Mr. W. R. McKeen, of the Union Pacific road.

MR. MCKEEN: I do not know that I can add much to the discussion. We have a new electrically driven shop at Omaha, Nebraska, in which constant current is used. The small machines are driven in series, and the larger ones are individual drives. We have a centrally located power plant distributing power to all loco-

motive department shops. We have not collected any data as to the efficiency of the plant, at the present time.

MR. H. H. VAUGHAN: I think it is in order for me to answer my associate members of the committee. Before doing that, I would refer to one or two questions that have been asked in regard to the cost of the power plant at Collinwood. The cost of this power plant only came into the report incidentally. The cost stated in the report is about $10 too low when we take into account a lot of additional items that can really be considered as chargeable against the power plant. We took into account the larger items, and consequently the amount has been questioned as being rather low for a complete power plant. The cost of bricking-in boilers, erecting engines and other things not charged in our contracts, but done by the railroad company, and a few things like that, bring the cost up to about $95 per horse-power. We have not yet analyzed the cost accurately enough to say exactly, but it does not affect the report in any way. It is simply an incidental item that was necessary to allow for the cost of investment in charging a certain amount against the tool.

Mr. Seley has abstracted this important report, but I do not think he brought out the point that we wish to emphasize in the report, and that is, that the entire difference in output that you have to obtain with a tool over which you have electrical control, as against the output you would have to obtain from a tool having the ordinary arrangement of belts and cones, is only two per cent. An additional two per cent in output will pay for the additional investment in speed control. It may be a little less than that on one system or a little more on another, but that is about the figure. We usually ask whether you have to obtain ten per cent, or twenty per cent, to pay for your investment. I believe, as we have shown, all you have to obtain is two per cent, and that decides at once that speed control is a thing you should have in any electrically driven shop. There is no question in my mind whatever that you obtain far more than that. There has been so much written on this question that it hardly seems worth while repeating it, as to the additional output you make by close control of speed. The question has been frequently stated that you can assume that you run within ten per cent of the possible speed, by

speed control, and twenty-five or thirty per cent of the possible speed by belt control, and, of course, obtain ten or fifteen per cent additional output. That appears to be exaggerated; but I would state that in watching the operation of speed control, you do obtain more than that. You are far more likely to get the men to run closer to the limit when they can change the speed by adjusting a lever than you are when they have to change belts and one thing and another.

It is a rare thing to see a man change speeds on a belt, in working different diameters of work. The men will do it only when they can do it by moving a lever. The thing is so easy to handle, they get into the habit of adjusting the work, to a certain extent. You may recollect that, when a similar discussion had before the Western Railway Club, that Mr. Gardner, whom most of us know, stated we should remember that if the speed control enabled you to run faster, it also enabled the men to run slower, and that was the thing they were looking for. I think he was taking a pessimistic view of the case; and as a matter of fact it is certainly up to the foreman if such a thing occurs. The results, I would say, show that the men are willing to take advantage of these means you put into their hands, when you give them an easy and convenient method of changing the speed of their tools; and I consider it is one of the most valuable things you can have around the shop, and certainly amply pays for itself on so small an additional investment.

Mr. Soule also rather questions the view that I wish to put forward, and that is, that the question whether you should drive every tool electrically in a shop or not — a new shop, of course — is up to the machine-tool builders. It really is. It does seem absurd to put a motor on to a small drill press, where the motor costs as much as the drill press. You say it is ridiculous — well, perhaps it is, but if you group-drive drill presses, you have also got to group-drive other tools, and you have to provide roof trusses to carry the countershafting, provide countershafting supports, line-shafting supports, and belting and hangers, and as nearly as I can judge from analyzing the costs at Collinwood, on one hundred tools, the results are in favor of the direct connection, provided, of course — and this is the peculiar feature — you get a

tool adapted for direct connection to the motor for the same price as you can get a tool with countershafting or direct connection.

I do not believe, in any tool costing from $150 to $200 (and the majority of the tools cost that much) that there is really anything to prevent us getting a tool ready for connection, with the gear on it, for a variable speed motor (not with a constant speed motor, with the necessary expensive gear changes), but ready for connection to a variable speed motor for the same price that we pay for a belted connection. If, in the gradual awakening of the machine-tool builders they are able to give us that, then it is going to pay to equip a shop with direct connection right through, rather than to go into group driving. The convenience and handiness of such a shop would be appreciable. I do not think there was ever a shop built that you did not find certain tools were wrongly placed the moment you began operation. You find the tools in the shop are not balanced up; you want to move a lathe from one place to another, or you want another drill press at a point in the shop where you at first thought there were enough. If the tools are electrically driven, there will be no trouble in this. A majority of tools do not require any foundations on the floors which are being put down in new shops, and it would be a convenience to move the tools around and adjust them as you want them, for the different groups of work in the shop.

With reference to the criticism of the three-wire, as against the four-wire system, I am rather sorry this question came up. I had hoped that the report would have sidetracked it. I think I am fair in assuming that Mr. Seley and Mr. Pomeroy have really expressed themselves in favor of the three-wire system. Personally, on the other hand, I would express myself as rather in favor of the four-wire system, and yet I do not feel that the thing is clearly enough demonstrated to take a very strong position on it. When you talk about complication, there is not much in it; it is a very small matter. The wires running in individual tools are small — you run one conduit from some convenient point underneath the floor to the controller. The men twist the wires together and they can as well run four through the conduit as three. The troublesome portion is getting the floor cut up and putting the conduit in. It is not the number of wires. I do not believe there is much difference whether you run three or four wires to a tool.

Mr. Seley referred to the lighting. If you do not have the 220-volt and the 110-volt system, you do not have to use the 220-volt arcs. We have not done it at Collinwood. We have used two 110-volt arcs in series and obtained absolutely satisfactory results. We have had a peculiar record there. In the six months' run of one hundred lamps, we have only had two "outs" from causes incidental to the lamp itself, which, I think proves conclusively that you are perfectly safe in running two arcs in series on a 220-volt circuit. No trouble whatever; light good. As to using 240-volt incandescents, I do not know the fine points sufficiently to say what the disadvantages are, but we have no trouble.

As to the point brought out in the report with reference to commutation, I believe it is not questioned by anybody that in running a one hundred per cent field regulation motor you have a point where that motor is running on the low voltage with a weakened field at practically the same speed that it runs on a high voltage with a full field. Now under these conditions the question of commutation on the low voltage is exactly the same as it would be on the high voltage, under one hundred per cent overload. If that is the case, a standard motor would be liable to give trouble under these conditions at its normal load, and I believe we are all coming to find that we do not run motors very much at normal load. Motors are run at all sorts of loads. They are run at one hundred per cent overload frequently and they have got to. The natural idea is to speed the tools up a little as soon as you find you can do it, and it is rather an expensive business to start. You have motors slightly underestimated, and they will run at overloads. Good overload capacity is an excellent thing. I do not doubt a motor will run at constant horse-power, at the horse-power you buy it for, all right on the three-wire system, and I am not prepared to state that a special motor will not run satisfactorily under the same overload that the ordinary motor does on the three-wire system, but I do say that there is a feature there which any one who purchases these motors should look into carefully, and that is the commutation limit when running with this weakened field. A standard motor will not do it. When I say standard motor, I am not referring to the same conditions that Mr. Pomeroy referred to — I mean an ordinary standard constant-speed motor, a motor

that you would use for constant-speed tools. I do not think that it is recommended by the three-wire system advocates that you should use these special motors on all the constant-speed tools — you simply use them on the tools on which you obtain field regulation, and unless that is done you would have two types of motors in the shop, and it is a nice thing to have one type of motor throughout a shop and be able to change them around and not carry too many spare motors.

We know that the first thing that gives trouble in a motor is the commutation. I think everybody will say the same thing, that where motors are used on planers or lathes and being run under heavy overloads, you have got to keep a man going continually after the commutators. You do not have to pay any attention to the heating limit; it is purely a question of bad sparking at the brushes, especially on planers. So that I simply wish to take the position in this report that the commutation limit on these motors, obtaining large range of speed by field control, should be looked into carefully; but I am not prepared to say whether the conditions can be met or not.

There is another thing worth while calling attention to — the three-wire system gives you a constant horse-power over the entire speed range. We are assuming that a constant horse-power is required. Now we do not really know to-day whether that is what is wanted, at least I have not seen any definite figures to show that it is; it may be or may not be. We have recently received a number of figures from the Case School of Applied Sciences, and we expect to work them up to be able to say something on the question, but are not ready yet. You can say definitely, that on planers, slotters, shapers and all that class of tools, you want a horse-power that varies with the speed, or perhaps the square of the speed. It takes nearly three times the power to double the speed of a planer, so that on those tools the four-wire system, in which the motor horse-power varies substantially as the speed, certainly has the advantage over a constant horse-power system, in which you would have to employ a motor large enough for the greatest power you required.

I might answer Mr. Soule with regard to the load factor. We have had some rather rough records taken at Collinwood, in which we took the number of tools in use and took the amperes on

the switchboard at the same time, and we find that the load factor runs closely to thirty per cent, including transmission losses, figured on the rated horse-power of the tools.

THE PRESIDENT: If there is no other member who wishes to speak on this subject, we will ask Mr. Seley to close the discussion.

MR. SELEY: As Mr. Vaughan has said, it probably would have been just as well to have omitted a discussion of the points of these two systems further than is done in the paper; and I must on this floor compliment and commend Mr. Vaughan for his fair treatment of the system which has my preference. I think, also, that he will concede we have treated his system fairly in the portion of the paper devoted to it.

We are going to try the three-wire system on a large scale. I might say that the Rock Island road is building a large shop at Moline, Illinois, to repair sixty engines a month, and it is hardly necessary to say we are going to put in the three-wire system. There will be individual motor-driven tools that require crane service, and a group-drive arrangement for the remaining tools. It may be that in a year or two hence I shall be permitted to give to the Association figures that are based on the performance at these new shops. I think we can afford to allow this matter to stand on the basis of the paper, believing there are two very good systems, the choice of which will be governed by local and other considerations.

THE PRESIDENT: We will now take up the report of the committee on "Locomotive Front Ends." Mr. H. H. Vaughan is the chairman of the committee.

The report is as follows:

REPORT OF COMMITTEE ON LOCOMOTIVE FRONT ENDS.

Mr. President and Members of the American Railway Master Mechanics' Association:

Your Committee on Locomotive Front Ends, appointed to assist the *American Engineer* and *Railroad Journal* in the tests being carried out at Purdue University along the lines of

(a) Proper dimensions for standard front end,

(b) Elimination of cinder valves,

(c) Elimination of the diaphragm,

begs to report as follows:

Since the conclusions derived from the tests being carried out by Purdue University, under the arrangements made with the *American Engineer,* were not immediately available when this committee was appointed, it was deemed inadvisable to hold an early meeting as instructed by the Executive Committee, and action was therefore deferred until Professor Goss presented a complete report. On receipt of this it was at once seen that a most valuable addition to existing information on the front end problem had been made and that the experiments certainly decided the relations of the stack and nozzle definitely and finally so far as it could be possible to do so on a testing plant. The conclusions are of such importance that we consider they should now be recorded in the report of this committee for the information of the members. The report presented also included a section devoted to a problem for further study. As this outlines as desirable a series of tests and is with one addition entirely concurred in by your committee this section is also included.

The sections above referred to which are reproduced from the *American Engineer* are as follows:

"Section VII.— A Summary of Results.

"The more important conclusions to be drawn from the results of the tests may be briefly stated as follows:

"1. All portions of the smoke box which are in front of the diaphragm have substantially the same pressure; and, consequently, a draft gauge attached at any point may be depended upon to give a true reading. (Article 15.)

"2. The resistance which is offered to the forward movement of the air and gases between the ashpan and the stack, may be divided approximately into three equal parts, which are: First, the grate and the coal upon the same; second, the tubes, and third, the diaphragm. It is significant that the diaphragm is as much of an impediment to draft as the fire upon the grate. (Article 16.)

"3. The form and proportions of the stack for best results are not required to be changed when the operating conditions of the engine are changed. That is, a stack which is suitable for one speed is good for all speeds, and a stack that is suitable for one cut-off is good for all cut-offs. In future experiments of draft appliances, therefore, results obtained from a single speed and a single cut-off should be deemed satisfactory. (Article 38.)

"4. Other things remaining unchanged, the draft varies with the weight of steam exhausted per unit of time; if the number of pounds of steam exhausted per minute is doubled, the draft, as measured in inches of water, is doubled; if it is halved, the draft value is halved. (Article 45.)

"5. As regards the form of outside stacks, either straight or tapered may be used. From a designer's point of view, the tapered is the more flexible, that is, with the tapered stack, the draft is less affected by

slight departures from standard dimensions. Incidental reasons, therefore, make the tapered form preferable. For best results, the diameter of a given straight stack should be greater than the least diameter of a tapered stack for the same conditions.

"The term 'tapered stack' used in this and other paragraphs signifies a stack having its least diameter or 'choke' 16½ inches from the bottom, and a diameter above this point which increases at the rate of 2 inches for each foot in length. (Article 44.)

"6. In the case of outside stacks, either straight or tapered in form, the height is an important element. In general, the higher the stack, the better will be the draft. (Article 43.)

"7. The diameter of any stack designed for best results is affected by the height of the exhaust nozzle. As the nozzle is raised the diameter of the stack must be reduced, and as the nozzle is lowered the diameter of the stack must be increased. (Article 41.)

"8. The diameter of a straight stack designed for best results is affected by the height of the stack. As the stack height is increased the diameter also must be increased. (Article 40.)

"9. The diameter of a tapered stack designed for best results, as measured at the choke, is not required to be changed when the stack height is changed. (Article 40.)

"10. The precise relation between the diameter of front end, and the diameter and height of stack for best results, is expressed by equations (Article 42), as follows:

"FOR STRAIGHT STACKS.

"When the exhaust nozzle is below the center line of the boiler,

$$d=(.246+.00123\,H)\,D+.19\,h.$$

"When the exhaust nozzle is above the center line of the boiler,

$$d=(.246+.00123\,H)\,D-.19\,h.$$

"When the exhaust nozzle is on the center line h is equal to zero and the last term disappears, and there remains,

$$d=(.246+.00123\,H)\,D.$$

"FOR TAPERED STACKS.

"When the nozzle is below the center line of the boiler,

$$d=.25\,D+.16\,h.$$

"When the nozzle is above the center line of the boiler,

$$d=.25\,D-.16\,h.$$

"When the nozzle is on the center line of the boiler, h becomes zero and

$$d=.25\,D.$$

"In all of these equations, d is the diameter of the stack in inches. For tapered stacks, it is the least diameter or diameter of 'choke.' H is the height of stack in inches and for maximum efficiency should always be given as large a value as conditions will admit. D is the diameter of the front end of the boiler in inches, and h the distance between center line of boiler and the top of the exhaust tip."

"SECTION VIII.— PROBLEMS FOR FURTHER STUDY.

"The Chicago & North-Western experiments (Master Mechanics' Association Proceedings, 1896) settled all questions relative to the form of exhaust pipe and tip, and the *American Engineer* tests, as described in this report, are equally conclusive concerning the proportions of an outside stack when used in combination with nozzles of different heights. When, therefore, designers are content to employ plain forms of construction, the whole problem of front end design may be considered solved. But conditions have of late arisen which enforce the use of stacks so short that the best proportions which can be given them do not yield satisfactory results. As a consequence, practice now tends along new lines for which there is little data that can be of service to the designer. That this deficiency may be supplied, it is necessary that the plan of tests already followed be extended to include other forms of mechanism. This is the more desirable since the results desired are not likely to be forthcoming from the road, but, on the contrary, can best be obtained from the laboratory. The fact, also, that a large amount of data which will serve as a base line from which efficiencies of other apparatus may be measured, has already been collected from the Purdue locomotive, and the fact, also, that the work already done suggests the elimination of certain variables and a corresponding reduction in the number of observations hitherto considered necessary, all suggest the desirability of continuing the investigation along the general lines of the *American Engineer* tests. If this should be agreed upon, the work should, in the opinion of the undersigned, be made to include the following subjects:

"(a) *Inside Stacks,* by which is meant a stack of usual form, but which instead of being entirely above the smoke box extends downward into the smoke box as well as out through its top. Where conditions are such that the portion of the stack extending outside of the smoke box is necessarily short, this arrangement is much used. The *American Engineer* tests have already included some observations on a straight inside stack of a single diameter, but the results obtained are not sufficient to serve as a basis for general conclusions. That the required data may be obtained, it will be necessary to employ stacks of at least three different diameters, and each diameter should have three different degrees of penetration into the smoke box. Some additional work, also, may need to be done to determine the best form of the lower portions of the stack. It will be sufficient to employ the tapered form of stack only, and to have the outside length of stack constant.

"The application of these stacks of different sizes will involve some cutting of the smoke box, and the change from one stack to another may make the progress of the work slow, and consequently, somewhat expensive, but the results will be worth the pains, for there is no other way by which the desired information may be obtained.

"(b) *Draft Pipes in Connection with Outside Stacks.*— It has been suggested that a draft pipe, or a combination of draft pipes, may be

accepted as a complete substitute for an inside stack, and many roads are using them, apparently with good results. The experiments should deal first with a single draft pipe which should be varied in diameter and vertical position until the best diameter and position can be definitely chosen. After this, the progess should be repeated in connection with a double draft pipe. A comparison of results thus obtained, with those obtained from the outside stack without draft pipes, should disclose the value of the draft pipes, and similarly a comparison of results obtained with those given by the inside stack should show whether the draft pipes are to be preferred to the inside stacks.

"(c) *False Tops Within the Smoke Box.*—A number of railroads are now following the practice of blanking off the upper part of the smoke box in such a manner that a stack of ordinary form may start from a point which is lower than the top of the boiler. The arguments in favor of such an arrangement are to be found in the fact that while the stack has the character of an outside stack, it can be made of greater length than would otherwise be possible. Whether there is any loss of efficiency resulting from the reduced height of the smoke box, and, if so, whether it equals or exceeds the gain resulting from the increased length of the stack, are important questions. To settle this, false tops of at least three different forms should be experimented with, in combination with stacks suitable for each form. A comparison of results with those obtained under the provisions of preceding paragraphs would show to what extent, if any, such an arrangement is superior to others which are more common.

"(d) *Diaphragm.*—As is well known, the diaphragm is not common in foreign practice, while in American practice its presence greatly impedes the forward movement of the gases. For this reason it would be well if it could be wholly omitted. It remains, however, to be determined whether there is any combination of nozzle and stack which in its absence will give satisfactory draft and at the same time draw equally on all tubes. The undersigned are not prepared to outline in detail a series of tests which will settle this question, but believe it to be of importance, and that the means to be employed will be apparent as the work outlined in the previous paragraphs proceeds.

"With full information concerning the relative value of the inside stack, draft pipes, the false top and the diaphragm, and with data which will permit any of these to be at once so designed as to give maximum efficiency, the problem of the front end, so far as it can be seen at present, is solved. While work of this character can be started and advanced slowly at small cost, it would be well if it could be vigorously pushed. To do this it will be desirable to have both the laboratory and the computing room manned at the same time, and to have assigned to the work an expert of sufficient ability and leisure to insure the prompt handling of all experimental results. Money will also be needed to supply and attach the special equipment and to defray the usual running expenses of the laboratory. While, therefore, much might be done at small cost if

plenty of time were available, the best policy requires that there be available a sum of from $5,000 to $7,000, at least $4,000 being available for the first year's work. Upon this basis the remaining problems of the front end could soon be definitely solved."

It might be stated that the engine on which these tests were made had a front end fifty-four inches in diameter, and the conclusions adapting the results obtained on this engine to those of a larger size were obtained by considering the diameter of the front end as a unit, and increasing the size of the stack in direct proportion. While this may be a correct method we feel that since all locomotives recently built or that are liable to be constructed in the future will have front ends of considerably larger sizes, this subject will not be left in a satisfactory condition unless further tests are carried out to confirm or correct this assumption.

We were advised by Professor Goss that it would not be possible to carry out further tests in continuation of the *American Engineer* series prior to June, 1903, on account of the conditions at Purdue University, and we also anticipated that considerable difficulty would be experienced in obtaining the use of a sufficiently large engine with the present demand for power. It was, therefore, decided to request those members who formed the original committee organized to assist in the *American Engineer* tests to make experiments in service to confirm the results obtained by Professor Goss. The majority were compelled to reply that, owing to the large amount of work then being carried on in their respective departments, they would be unable to assist during the present year and only three series of tests have been carried out. These have only been partially made and the results are not sufficiently complete to present in this report, although it may be stated that they practically confirm the conclusions arrived at on an engine having a front end of the same size as that used at Purdue University, but leave it open to question whether these results are immediately applicable to engines having a considerably larger front end. We are pleased to be able to announce that through the courtesy of one of the members of this association, Mr. J. F. Deems, General Superintendent of Motive Power and Rolling Stock, of the New York Central & Hudson River Railroad and Lake Shore & Michigan Southern Railway, arrangements have been made by which a large modern engine, having a front end seventy-five inches in diameter, will be available to allow this series of tests to be completed. This will enable the determination of the correct unit to be used for stack diameters to be made, and a further series of tests carried out along the line recommended by Professor Goss. Your committee, therefore, asks to be continued in order that during the coming year it may carry out the purpose for which it was appointed.

H. H. VAUGHAN, Chairman,
F. H. CLARK,
A. W. GIBBS,
W. F. M. GOSS,
ROBERT QUAYLE,
Committee.

CLEVELAND, OHIO, May 25, 1903.

MR. H. H. VAUGHAN: Mr. President and Gentlemen,— I am exceedingly sorry that this report is little less than a carefully veiled announcement that we have not done anything. The question of carrying out tests on a testing plant does not depend entirely upon your wishes; it depends on whether the testing plant is available, and on other considerations. I believe the committee did the right thing in not taking any action until the results of the tests carried out by the *American Engineer* were available. We had to know what the results were and examine them carefully before going ahead and spending any more money. This report really consists of an extract from the *American Engineer,* giving the results obtained from the tests made for them, and I believe that these results establish the relation of stacks and nozzles as closely as they ever will be established for a 54-inch front end. As you will see in the report, the committee thinks that these results should not be taken as applying to any size front end, simply by increasing or diminishing the diameter of the stack in proportion to the diameter of the front end. We think that, as nearly all new engines, and practically all those that will be built in the future, have large front ends, 70 inches and up to 80 inches in diameter, that it is necessary to carry out sufficient tests on a large front end to check up the relation between the two sizes. We do not think that such series of tests will have to be as elaborate as the one just carried out, and that on the completion of that test we can go on to some other subjects referred to in Professor Goss' recommendation. I very much hope that this meeting will continue the committee as requested, especially as we hope to get, in October, an engine having a 75-inch front end, which will go on the Purdue testing plant and on which these tests can be continued.

MR. F. H. CLARK: As one of the members of the committee, and at the request of the chairman, I undertook to make some tests in road service to confirm the results obtained in the laboratory; but owing to the pressure of other work we were unable to get the material out in time to report the results of the tests to the committee so they could be incorporated in the report. We began with an 18 by 24 inch engine, 54-inch stack, and found that, according to the rule recommended the minimum diameter with a taper stack should be 14 inches. We have been using 13-inch

stacks pretty generally on these engines, although in some cases we use the 14-inch stack. We have not as yet made any experiments with larger engines, but I will read for the benefit of the members present a report by Mr. Colwell, master mechanic of the Galesburg Division, on results obtained by Mr. Sweney, assistant road foreman, who made some road tests with engines fitted with various stacks.

This test was made on Class A-1 passenger engine No. 1305, between Galesburg and Quincy. The engine was tried with three different stacks as follows: First, with our standard 14-inch choke cast-iron stack, 50 inches high for Class H engines; second, with the standard 13-inch choke cast-iron stack, 56 inches high, for Class A engines, and third, with the "experimental" 14-inch choke sheet-iron stack, 56 inches high. Two round trips on passenger between Galesburg and Quincy were made with each stack. So far as the steaming of the engines was concerned there was no apparent difference in favor of either one of the three stacks. The matter of vacuum produced in the smoke box, the experimental stack 56 inches high, with 14-inch choke, showed up a trifle better than the cast-iron stack 50 inches high, with same size choke. Both 14-inch choke stacks excelled the 13-inch choke in this respect, the percentage in favor of the "experimental" 14-inch choke stack over the 13-inch choke being 3.8, as against 3.1 for the standard 14-inch choke cast-iron stack. The size of the exhaust tip in engine No. 1305, while these tests were being conducted, was 4½ inches.

A second test was also made on Class A-1 freight engine No. 1090, between a 13-inch choke, 56-inch cast-iron stack, and the 14-inch choke 56-inch sheet-iron "experimental" stack, and it was found that the engine steamed better with the larger stack.

Mr. Vaughan: I omitted to say something in reference to this subject and that is, in designing stacks in accordance with Professor Goss' recommendation, it is very important to notice that the tapered stack referred to by Professor Goss has a one-in-six taper. Many roads are using taper stacks of a size in accordance with the report, and because they do not work as well as other stacks you have on engines, assume the report is wrong, whereas the stacks are in some cases of a different taper. If it is desired to use a stack of an intermediate taper the best way to do, I think, is to lay out the straight stack recommended by Professor Goss and the taper stack, one above the other, and it is easy to judge the right size of stack for the taper you wish to use.

I might supplement the statement read by Mr. Clark by saying

we have also made tests on engines having 54-inch and 67-inch front ends, and as far as we can tell by road tests, which are the most unsatisfactory things you can make, we believe Professor Goss' report gives you exactly the right size of stack. Mr. Quayle, of the North-Western, made some tests, and I believe, as nearly as I can judge from the report I received from him, they substantiate Professor Goss' report on the 54-inch front end, but appear to show that the North-Western experiments do not quite agree with him on the larger front end. I believe the disagreement is due to their not having adopted the one-in-six taper, and consequently they have obtained a different stack. We have not had time to work over that proposition very carefully, or we would have presented results at this meeting, but two or three other roads are experimenting on these different sizes of stacks, trying to check up the reports on the testing plant. The proper way to do it is to check up on the testing plant for a larger front end.

THE PRESIDENT: I understand Mr. Bentley, of the North-Western, is present, and perhaps he can give us some information on this subject.

MR. H. T. BENTLEY: Tests were made on our road in accordance with the suggestions made by the committee, but they were in the hands of one of our special apprentices. I did not follow them up very closely, and am sorry to say I am not able to give any data.

MR. QUEREAU: The time is not very far back when results obtained in the laboratory were rather smiled at and frowned at by the average railroad man. They were called theoretical, and possibly all right in the laboratory, but did not amount to much in practical service. I think there has been a revolution in the last few years, and justly so, in the conclusion concerning these matters, and it has come to be recognized that only by laboratory tests conducted by those who are competent, can actual results be obtained and fair conclusions made, because in the laboratory all conditions except the one you are testing can remain constant, and it is only under such conditions that just and fair conclusions can be made. I mention this because it seems to me there is still lingering too much in the minds of many the idea that laboratory

tests must be proved on the road. I do not know that that was the idea of the committee in making the road tests, and I am not criticizing them for it; I am simply expressing a personal opinion that such road tests as indicated by Mr. Vaughan can not compare, in justice, in reasonableness, or in conclusiveness, with the results obtained in the laboratory.

Those who are familiar with the report of the Master Mechanics' Committee on Front-end Arrangements will remember that they found it practically impossible in the laboratory to maintain a constant thickness of fire, that while they were undertaking to determine the effect of different proportions of the stack to the nozzle, they found that the conditions in the fire box were so constantly varying that no just conclusion could be drawn, and they, therefore, did the sensible thing and bricked off the grate, had a constant opening and used oil for obtaining their heat, thus bringing us back again to the proposition of having all conditions constant, saving the one they were testing. It seems to me we must have our final conclusions based on laboratory tests, and that it is largely a waste of time to undertake to draw conclusions from road tests. I have had considerable experience in such matters, and not only as a matter of general principle, for the reasons given, but as the result of personal experience, I am convinced our final conclusion will be reached by laboratory tests in competent hands.

It seems to me they have been and are now in competent hands, and we can look for good results which will work out in practice, assuming, of course, that those who undertake to put them in practice will observe the conditions and the measurements, such as the rate of taper in the stack, which were observed by the committee making the test.

MR. WILLIAM FORSYTH: I notice that the New York Central expected to make a test with a stack designed on the committee's proportions. I would ask Mr. Quereau or Mr. Deems what they have done about that test?

MR. QUEREAU: I do not know anything about it; possibly Mr. Waitt would know.

THE PRESIDENT: Mr. Waitt is not present just now.

MR. FORSYTH: I ask, further, what provision is made to carry

on the rest of the work recommended by Professor Goss in his paper and which the committee has embodied in its report?

MR. VAUGHAN: The committee was instructed to notify the Executive Committee of the amount required, and it was understood they would take action to allot the money necessary to carry out the tests. That was the action at the last convention, I believe, What we ask is to be continued, so that that provision is still in force, especially now that we have obtained the loan of an engine for the work.

MR. DAVID BROWN: I think when the committee tests the engine they anticipate getting now they will find that a great deal of their former work will be changed. In other words, they have been experimenting on engines that we are discarding, with small boilers, long stacks, etc.; they can regulate their chokes, no doubt, but I am pleased to note they are increasing the diameter of the stacks still further. When they get a modern large boiler, with short stack, I am afraid our former tests and recommendations will be changed somewhat. In place of the long stack in which they could regulate the choke, they will have a short one with not sufficient length to do so; they will probably find a straight stack the most desirable, as they will not be confined to a given length from tip of nozzle to choke; they will have a greater range on the short stack by being straight, as it matters not where the steam would strike the stack as long as it was filled to form the vacuum. It is to be hoped the engine that will be put on the testing plant at St. Louis will be a modern one.

MR. H. F. BALL: I move the committee be continued for another year.

MR. POMEROY: I want to offer an amendment to Mr. Ball's motion. In view of the admirable report of progress made by the committee and the substantial work put upon it, I think the committee should not only be continued, but to have a vote of thanks for the work performed.

MR. BALL: I accept the amendment.

PROFESSOR GOSS: Before the question is put, permit me to say that while I am in sympathy with the motion which Mr. Pomeroy has just made, and while I would not deprive the committee of any

credit which the Association is disposed to give it, I would emphasize the important part taken by the *American Engineer*. Being a member of the committee, I can speak with frankness. About all that the committee has done has been to have a few meetings and to accept the work which has come to them through the enterprise of the *American Engineer*. I hope, therefore, that in extending thanks to the committee, we will not forget the indebtedness of the Association to the *American Engineer,* which has supplied the funds to pay the routine expenses of the laboratory throughout this research.

MR. POMEROY: In view of the modesty of the committee, I think they are all the more entitled to the vote of thanks, just the same.

The motion of Mr. Ball, as amended by Mr. Pomeroy, was put and carried.

THE PRESIDENT: I have great pleasure to announce that the Hon. J. N. Dickey, a member of the Board of Railroad Commissioners of the State of New York, is here to attend this meeting. He is now at the hotel across the street, and I have asked him to attend our session at 12 o'clock.

I will ask Mr. Pomeroy and Mr. Lonergan to escort Mr. Dickey to the meeting at the appointed time.

The next business is the report of the Committee on "Pipe Unions," by Mr. C. H. Quereau, chairman.

Mr. Quereau presented the following report:

REPORT OF COMMITTEE ON STANDARD PIPE UNIONS.

To the Members:

Your committee was instructed to correspond with manufacturers, presumably with a view to suggestions and criticisms. As this was very thoroughly done by the committee of the American Society of Mechanical Engineers, before making their final report, your committee has received no suggestions which had not been previously considered.

We have undertaken to interest the National Association of Stationary Engineers and the Master Steam Fitters' Association with a view to securing their coöperation in the adoption of a standard union. No reply has been received from the Master Steam Fitters' Association.

Mr. Robert G. Ingleson, president of theNational Association of Stationary Engineers, has shown considerable interest in the matter and

through him copies of our report of last year were distributed among the members of his association. The matter will be presented for discussion and action at the next convention of the stationary engineers and the report of your committee will be printed in the June number of the *National Engineer,* which is the official publication of the National Association of Stationary Engineers. He has also urged that this association send one of its members as a delegate to the next convention of the steam engineers. If this invitation is accepted, we are impressed that good will come of it. It should at least result in a better understanding of the subject from a different standpoint.

The Illinois Malleable Iron Company of Chicago, finding it necessary to make new patterns for a one-inch union, requested that they be supplied with a sample of the union recommended as a standard by the American Society of Mechanical Engineers and this Association, believing they could judge of its merits better than they could from the blueprints. After receiving the authority of our Executive Committee, we had a dozen standard unions made and sent one to the Illinois Malleable Iron Company. The balance we still have for distribution, in case other manufacturers desire samples. So far the Illinois Malleable Iron Company have not notified us as to what decision they have reached.

We would recommend that this Association, through its Executive Committee, appoint a delegate to attend the convention of the National Association of Stationary Engineers, to be held in Evansville, Indiana, September 1, 1903.

Master Mechanics' Committee:	*Master Car Builders' Committee:*
C. H. Quereau, Chairman,	C. H. Quereau, Chairman,
Thomas Fildes,	W. H. Lewis,
E. M. Herr.	Thomas Fildes.

The President: The subject of the report is open for discussion.

Professor Hibbard: I move that the Association approve the recommendation of the committee regarding the appointment of the delegates.

Motion seconded and carried.

Mr. Forsyth: This subject has been before the Association for quite a number of years, and as I understand it, the American Society of Mechanical Engineers has agreed to adopt a standard. Is that correct?

Mr. Quereau: The American Society of Mechanical Engineers can adopt no standard.

Mr. Forsyth: I understand they reached a point where they

presented drawings and figures which it was to be equivalent to the adoption of a standard and which they put forth as the best work they can do.

MR. QUEREAU: Yes.

MR. FORSYTH: What has been done by the other associations?

MR. QUEREAU: Nothing. The recommendations of the American Society of Mechanical Engineers have been approved by the committees appointed both by the Master Car Builders' Association and the Master Mechanics' Association, and an effort is being made, as indicated in the paper, to interest other associations, such as the Master Steam Fitters' Association, the National Association of Stationary Engineers, and other associations, with a view of discussing the matter and getting their approval of the suggestions. It has been practically impossible to interest the manufacturers up to date, and it was thought that this could be accomplished only by showing the manufacturers that there was a demand for a standard union. The matter stands in that way at the present.

MR. FORSYTH: Then the Master Mechanics have adopted a standard?

MR. QUEREAU: No; the committee appointed by the Master Mechanics has recommended the standard proposed by the American Society of Mechanical Engineers.

MR. FORSYTH: Why do they not adopt it?

MR. QUEREAU: They want to hear from the manufacturers and want to interest other associations.

MR. FORSYTH: It seems to me the best way to get these associations interested is to say we have adopted a standard and ask them to use that standard. The matter has been before this Association so long it should now be closed up. The longer we keep dragging it along this way and appointing delegates and things of that kind the longer the matter will be unsettled; but if these outside associations referred to knew that this Association had adopted a standard which had been worked out by the American Society of Mechanical Engineers as the best design which it could produce, and which met with the approval of this Association, they

would be then inclined to adopt it and go into the manufacture of it. I think very little will be accomplished by simply sending a delegate to the Steamfitters' convention and more could be accomplished if we took definite action and adopted this standard.

MR. ANGUS SINCLAIR: I have followed the progress of the efforts being made to establish standard pipe unions. I do not think this Association or the Master Car Builders' Association should pay the least attention to the recommendations of the American Society of Mechanical Engineers. They stand aloof all the time from establishing any standards. I never could see why they should stand aloof. They would have a good deal more influence upon the manufacturers of the country if they took a positive stand and established standards and said to others, "Here is our standard, follow it." It is generally understood that they have a standard for the horse-power of the steam boiler, for instance, yet they have not, as a matter of fact; and they merely seem to make confusion worse confounded in whatever they put their hands on in the way of standards; and I think the American Railway Master Mechanics' Association should follow the recommendation of Mr. Forsyth and adopt the standards, the same as with screw threads and other things that others followed, and settle the matter so far as we are able to do it.

THE PRESIDENT: I hope you will be free to express your opinion on this matter, gentlemen.

MR. LEACH: I would ask the committee if there is any objection that it knows of to our accepting Mr. Forsyth's suggestion, to the effect that we express our opinion that we will adopt this as standard?

MR. QUEREAU: I will second that motion, if I understand it — it was to accept the standard presented last year. Is that your motion?

MR. LEACH: I did not make the motion.

MR. FORSYTH: I offer that as a motion, Mr. President, that the standard for pipe unions, which has already been considered by the committee on the subject, be adopted by this Association.

MR. LEACH: I second the motion.

MR. QUEREAU: I believe that is the proper action to take.

Your committee of last year, which was the same as this, practically, made that recommendation. We were simply carrying out the instructions of this Association in continuing the work along the lines reported by us this year. I am in hearty sympathy with the motion.

THE PRESIDENT: You will withdraw your recommendation that the committee be continued?

MR. QUEREAU: I see no use in continuing the committee. That recommendation was made because last year this Association instructed the committee to do what they have done. The committee recommended a year ago the adoption of the standard. The Association saw fit not to do this, but to continue the committee to investigate along different lines. The wisest thing to have done last year, and the wisest thing to do now, is to adopt the standard, because it has been carefully considered by experts, by pipe manufacturers and manufacturers of fittings, and I believe is the best we can get.

MR. E. W. PRATT: I would move to amend Mr. Forsyth's motion by inserting the words "by and with similar approval of the Master Car Builders' Association"; that is, that the standard be adopted by this Association by and with the approval of the Master Car Builders' Association.

THE SECRETARY: In regard to Mr. Pratt's amendment, the Master Car Builders' Association will have a similar report upon the subject of pipe unions, and they will probably be governed in their action somewhat by the action the Master Mechanics take in regard to its adoption; and I hardly think it would be advisable to take up Mr. Pratt's amendment. Let each association act on its own cognizance.

MR. FORSYTH: I would be glad to accept Mr. Pratt's amendment to the extent of advising the Master Car Builders' Association of our action.

THE PRESIDENT: The motion is that we adopt these standards and advise the Master Car Builders' Association of our action. Mr. Pratt's amendment not being seconded, the original motion will be put.

The original motion of Mr. Forsyth was put and unanimously carried.

THE PRESIDENT: The next business is the report of the Committee on "Locomotive Forgings and Specifications for Driving and Truck Axles," Mr. F. H. Clark, chairman.

The paper is as follows:

REPORT OF COMMITTEE ON SPECIFICATIONS FOR LOCOMOTIVE AXLES AND FORGINGS.

To the President and Members of the American Railway Master Mechanics' Association:

Your present committee is the result of a consolidation of two committees, one of which made a preliminary report on standard specifications for locomotive driving and truck axles at the last meeting, and the other of which was appointed after last meeting to consider the subject of locomotive forgings. The subjects being so closely related it was finally decided to consolidate the two committees. It is understood that the work expected is as follows, although the instructions under which the committee is working are not entirely clear:

First: To submit specifications for locomotive driving and truck axles.

Second: To submit specifications for locomotive forgings.

Third: To coöperate with the American Society of Mechanical Engineers, the American Institute of Mining Engineers, and the American Society for Testing Materials, with a view of bringing about standard specifications for locomotive axles and forgings. Your committee, therefore, in presenting the specifications below does not expect their adoption as standard, but hopes that a discussion of the subject will enable the committee to take the matter up with the other Associations named with a better understanding of the wishes of this Association.

Your committee has thought it well to present three distinct specifications; one for steel driving and engine truck axles, another for locomotive forgings for the use of such roads as are in the habit of buying finished forgings of outside concerns, and a third specification for the use of railroads and locomotive builders buying billets for the manufacture of forgings at their own works.

PROPOSED SPECIFICATIONS FOR LOCOMOTIVE DRIVING AND ENGINE TRUCK AXLES.

MATERIAL.

Open Hearth Steel.

CHEMICAL REQUIREMENTS.

Phosphorus, not to exceed	.05 per cent
Sulphur, " "	.05 "
Manganese, " "	.60 "

Physical Requirements.

Tensile strength — not less than 80,000 lbs. per sq. inch.
Elongation in two inches, not less than 20 per cent.
Reduction in Area, not less than 35 per cent.

Number of Tests.

One test per melt will be required, the test specimen to be taken from either end of any axle with a hollow drill, half way between the center and the outside, the hole made by the drill to be not more than two inches in diameter, nor more than 4½ inches deep. The standard turned test specimen, one-half inch in diameter and two inches gauge length, shall be used to determine the physical properties. (See Fig. 1.)

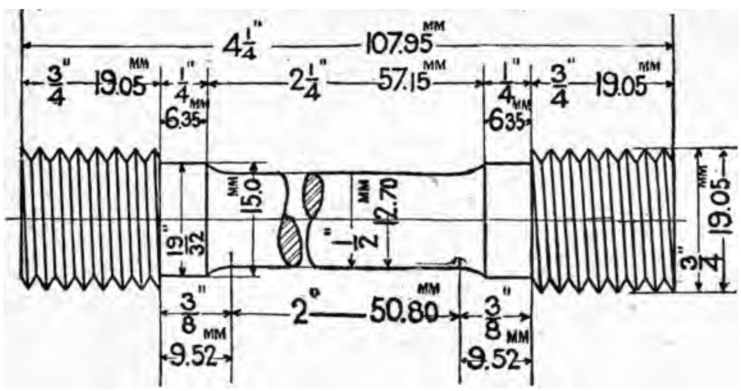


Fig. 1.

Drillings or turnings from the tensile specimens shall be used to determine the chemical properties.

Stamping and Marking.

Each axle must have heat number and manufacturer's name, plainly stamped on one end, with stamps not less than ⅜ inch, and have order number plainly marked with white lead.

Inspection.

All axles must be free from seams, pipes, and other defects, and must conform to drawings accompanying these specifications.

Axles must be rough-turned all over, with a flat-nosed tool, cut to exact length, have ends smoothly finished and centered with sixty-degree centers.

Axles failing to meet any of the above requirements, or which prove defective on machining, will be rejected.

The above specification for locomotive driving and truck axles is believed to be fair to both manufacturer and purchaser. The physical test outlined is one which should insure proper hammer work and it has also the following further points in its favor:

(1) It does not show the manufacturer which axle is to be selected for test.

(2) The axle tested is not destroyed, but is available for use if it meets the requirements.

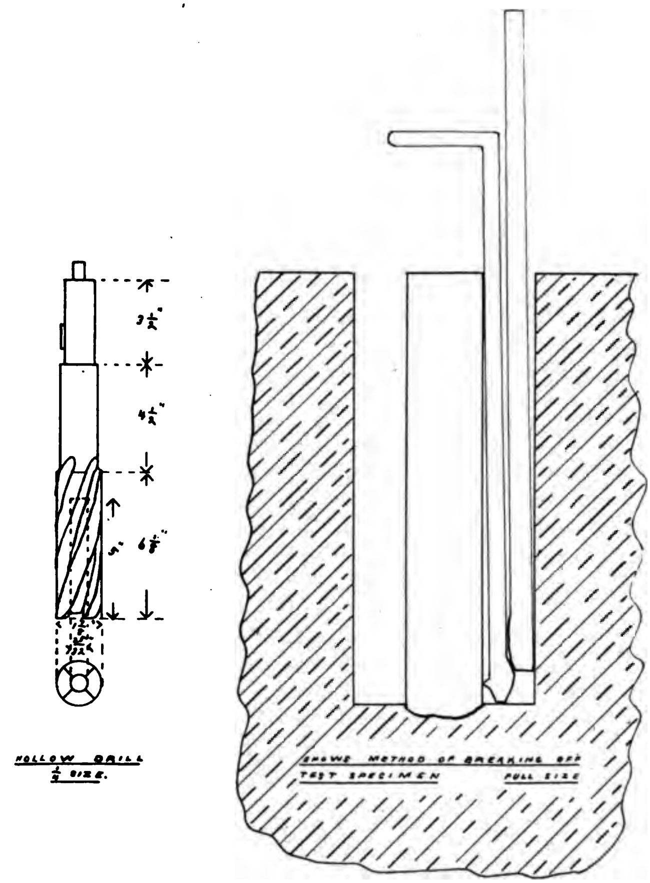
(3) The test may be used in the purchase of small lots, most orders from railroad companies being for from six to ten axles.

(4) The test does not require a discard and in no way adds to the cost of the axle.

(5) It furnishes the manufacturer with a check of the work done in his plant.

(6) The test is one largely used by the United States Government for forgings.

A method of breaking off test specimen and tool for obtaining same from end of driving axle are shown.



TOOL FOR OBTAINING TEST SPECIMENS FROM END OF DRIVING AXLES.

PROPOSED SPECIFICATIONS FOR LOCOMOTIVE FORGINGS.

MATERIAL.

Open Hearth Steel.

CHEMICAL REQUIREMENTS.

Phosphorus, not to exceed	....	.05 per cent
Sulphur, " "	....	.05 "
Manganese, " "	....	.60 "

PHYSICAL REQUIREMENTS.

Tensile strength, not less than 80,000 lbs. per square inch.
Elongation, not less than 20 per cent in two inches.
Reduction in Area, not less than 35 per cent.

NUMBER OF TESTS.

One test per melt will be required, the test specimen to be cut cold from the forging, or full sized prolongation of same, parallel to the axis of the forging and half-way between the center and the outside.

The standard turned specimen, one-half inch in diameter and two inches gauge length, shall be used to determine the physical properties. (See Fig. 1.) Drillings or turnings from the tensile specimen shall be used to determine the chemical properties.

STAMPING AND MARKING.

Each forging must have heat number and name of manufacturer plainly stamped on one end with figures not less than 3/8 inch and have order number plainly marked with white lead.

INSPECTION.

All forgings must conform to drawings which accompany these specifications, and be free from seams, pipes, and other defects.

Any forgings failing to meet any of the above requirements, or which prove defective on machining, will be rejected.

The above specification for locomotive forgings is based upon the recommendations of the American Society for Testing Material, with some slight modifications, which, it is believed, will tend to improve the product. The physical test is substantially the same as that recommended above for testing locomotive driving and truck axles, and the same arguments may be used in its favor.

PROPOSED SPECIFICATIONS FOR STEEL BLOOMS AND BILLETS FOR LOCOMOTIVE FORGINGS.

Material.

Open Hearth Steel.

Physical Requirements.

Grade "A:"
- Tensile strength, 70,000 lbs. per square inch.
- Elongation in two inches, 20 per cent.

Grade "B:"
- Tensile strength, 80,000 lbs. per square inch.
- Elongation in two inches, 17 per cent.

Chemical Analysis.

Grade "A:"

Carbon	.25 to .40	per cent
Phosphorus, not to exceed	.06	"
Sulphur, " "	.06	"
Manganese, " "	.60	"

Grade "B:"

Carbon	.35 to .50	per cent.
Phosphorus, not to exceed	.05	"
Sulphur, " "	.05	"
Manganese, " "	.60	"

Number of Tests.

One test per melt should be required, the test specimen to be cut cold from the bloom, parallel to its axis and half-way between the center and the outside. The standard turned test specimen, one-half inch in diameter and two inches gauge length, shall be used to determine the physical properties. (See Fig. 1.) Drillings or turnings from the tensile specimen shall be used to determine the chemical properties.

Stamping and Marking.

Each bloom or billet must have heat number and manufacturer's name plainly stamped on one end, with stamps not less than ⅜ inch and have order number plainly marked with white lead.

Inspection.

Blooms and billets must be free from checks, pipes, and surface defects. Any blooms or billets chipped to a depth greater than one-half inch will be rejected.

Any billet or bloom failing to meet the above requirements will be rejected and held, subject to disposal by manufacturers.

Inspector to have the privilege of taking drillings from the center of the top bloom or billet of the ingot in order to determine the amount of segregation.

Grade "A" is blooms or billets for rod straps and miscellaneous forgings.

Grade "B" is blooms or billets for driving and truck axles, connecting rods, crank pins and guides.

F. H. CLARK, Chairman,
J. E. SAGUE,
S. M. VAUCLAIN,
L. R. POMEROY,
Committee.

CHICAGO, ILLINOIS, June 6, 1903.

MR. CLARK: I do not believe it is necessary to read this report; the most of it is not very good reading matter anyway, but I want to make a few remarks in reference to it. As stated on page 1, the committee is expected to confer with other associations on the subject under consideration. The American Institute of Mining Engineers has done nothing, and I understand that it is unlikely that any action will be taken by that association. The American Society of Mechanical Engineers has a committee on specifications, but I understand that it has not yet made a report. The American Society for Testing Materials presented specifications about two years ago which have been discussed by that society, and the members of your committee have been invited to attend their meeting next week at Delaware Water Gap and to present their report to that association with such comments as may seem desirable after your discussion. For this reason we are particularly desirous that the members make any suggestions that will tend to improve the specifications recommended. We understand that it is proposed that the results of the committee's work, if satisfactory, are to be brought before the International Railway Congress in 1905. I believe there is nothing novel to the members of the Association in the specifications recommended, with the possible exception of the manner of taking the test piece, and I want to call particular attention to what is said on page 3 of our report concerning it and to one of the methods used for breaking of the test piece as shown on page 4. The arguments in favor of the test are as follows:

(1) It does not show the manufacturer which axle is to be selected for test.

(2) The axle tested is not destroyed, but is available for use if it meets the requirements.

(3) The test may be used in the purchase of small lots, most orders from railroad companies being for from six to ten axles.

(4) The test does not require a discard and in no way adds to the cost of the axle.

(5) It furnishes the manufacturer with a check on the work done in his plant.

(6) The test is one largely used by the United States Government.

Mr. Sague, one of the members of the committee, has been abroad for some time and has delegated his work on the committee to Mr. Kincaid, Engineer of Tests of the American Locomotive Company, to whom the committee is indebted for much valuable work. I believe Mr. Kincaid is present, and I would recommend that he be allowed the privileges of the floor during the discussion of these specifications.

THE PRESIDENT: The report is now before the meeting for discussion. You have heard the recommendation of the chairman of the committee that Mr. Kincaid, of the American Locomotive Works, be given the floor.

On motion, the privileges of the floor were extended to Mr. Kincaid.

MR. J. F. KINCAID: I would like to speak particularly on the method of cutting test pieces from axles. We have recently made some tests at Schenectady along this line, and find that it is very little trouble to make the drill in our own toolroom, and we can get the test in forty-five or fifty minutes. Ordinarily, the horizontal boring mill is the best tool to use, but the chisel is the only difficult part. If the piece can be properly nicked, a few pries with the chisel will remove the test piece and it is in good condition to be prepared for the testing machine.

As regards the specification itself, I have no suggestions to make, unless it is that the manganese should be increased a trifle. The standard practice of many of the mills is to have the manganese higher than .60. An increase in manganese increases the cost of manufacturing to a certain extent, and for that reason the manu-

facturers are not liable to put in more than is absolutely necessary for the best interests of the steel itself. That is the only comment I would make on the specifications. It would be of great help to the committee if members of the Association would make analysis and physical tests of all forgings which fail and report this information to the chairman, or send drillings which the chairman could arrange to have analyzed. In this way data could be compiled which would enable us to fix more satisfactory limits on the chemical requirements of the specification.

MR. L. R. POMEROY: I rise to emphasize what Mr. Clark has said by a statement that your committee, which is expected to meet in conjunction with the committees of the other societies and also with the committee of the American Railway Association, desires to get all the information possible as to the wishes and experience of the members present; and one of the objects in presenting this specification as a tentative specification is in the hope of inviting such discussion and drawing out from the members information that would be useful in aiding the committee to represent your Association before the International Railway Congress with proper intelligence and a correct understanding of your wishes. If any member has any criticisms or suggestion to offer, we would be very glad to have them presented.

MR. H. F. BALL: I would like to ask the committee whether it considered the elimination of truck axles from this specification, confining the specifications to driving axles alone, and having the truck axles conform to the M. C. B. standard axle specifications?

MR. CLARK: I would say that the committee considered that matter, but, as you know, the present specifications for car and tender axles include drop tests, and in view of the many different sizes of engine truck axles and the probability that in the case of any certain engine-truck axle there would be no corresponding size of tender or car axles, we concluded not to attempt to draw up specifications combining the two.

MR. POMEROY: I will say further, for the information of the Association, that the original specifications of the International Bureau of Tests make no distinction between engine-truck axles

and tender axles, and that was the first exception that the committee took to these specifications, because the sizes of the engine-truck axles were such that the drop test would not be feasible nor available, and on this the committee were a unit, and hope that the Association will sustain us, that there should be a distinction between engine-truck axles and tender axles, and consequently add another clause to the specification. We trust the Association will approve the addition of such a clause. That was one of the points on which we desired further information and instruction, so that we can intelligently represent the Association.

THE PRESIDENT: We are anxious to get all the information we can on this subject. The committee desires it especially; but if there is no further discussion we will declare the subject closed.

We will now take up the topical discussion "Range of Weights of Principal Parts of Locomotives (which are too heavy to be lifted by hand) for Use in Determining the Capacities of Cranes and Hoists." The topic will be opened by Mr. R. H. Soule.

MR. SOULE: Mr. President and Gentlemen,— In my own experience I have often felt the necessity for some source of information that I could refer to, to ascertain the heaviest weight of certain parts of locomotives in order to properly proportion the hoist or crane to lift that particular part of the work. In that connection, I have obtained from the Baldwin Locomotive Works and the American Locomotive Company complete detailed statements of the weights of the parts of eight locomotives, four from each of these two builders. The lists were given in great detail, more so than we should care to record in our proceedings, and I have therefore picked out from the lists sixty-two different parts, and have selected the heaviest weight, that was reported for each individual part and listed them. I shall file this statement with the Secretary to be printed in the Proceedings, if so ordered, but I will at this time speak of only a few of the weights that are given.

The heaviest weight of a complete boiler that is recorded is that of the Santa Fe tandem-compound Decapod, made by the American Locomotive Company, which weighs 66,313 pounds. That indicates at once that in order to be safe and leave some little margin, a general boiler-shop crane which is going to handle all kinds of boilers should not be of less than thirty-five tons capacity.

The next item worthy of note is that of cabs; the heaviest wooden cab reported weighs 1,520 pounds, and the heaviest steel cab weighs 2,690 pounds, showing at once that, in general, steel cabs will weigh over 1,000 pounds more than wooden cabs. A full set of frames on the engine referred to weighs 21,200 pounds, which indicates that a ten-ton crane is hardly sufficient to handle them, and will probably require a fifteen-ton crane. A pair of cylinders bolted together complete in the case of the same heavy Santa Fe tandem-compound Decapod engine will weigh 27,420 pounds, showing at once that nothing less than a fifteen-ton crane would be safe to provide for handling that class of work. The heaviest driving axle reported, referring to the same engine, weighs 1,875 pounds; a pair of driving wheels on axles, the same engine, being the main wheel with eccentric and straps on, weighs 9,375 pounds. Engine truck complete, Atlantic type, New York Central engine, weighs 10,250 pounds, something over five tons. The tender tank reported by the Baldwin Company weighs 13,680 pounds, showing at once that a seven and one-half ton crane is necessary; the tender truck, complete, 9,060 pounds. the tender, complete, without coal or water, 48,900 pounds.

MR. C. A. SELEY: I do not know that I got all of Mr. Soule's idea, but I hope the details of this report will not be confined strictly to the weights given by him, but will cover average weights of different types, if he has the information or it can be secured. I think any amount of that information accessible to our members would be a good thing to have. I would like to see all the figures given in this connection that we can possibly get hold of.

MR. D. VAN ALSTYNE: I think we need more detailed information as to the weights of parts of locomotives, not only for shop design, but also for locomotive design, and we could more intelligently design if we knew the weights of detailed parts of various kinds and sizes of locomotives. I think the more of that kind of information we can get into the report the better.

MR. SOULE: If so desired, I will file with the Secretary the original statements received from the Baldwin Locomotive Works and the American Locomotive Company, which give the details in full for eight different engines; but I would like to have it understood that the lists are not complete in a certain

sense; for example, one engine may have been reported upon in very great detail, perhaps one hundred parts covered, whereas some of the other engines may have had only twenty or thirty different parts reported on; that is to say, because you have the detail weights of eight engines reported, it does not necessarily mean you will find there the weights of eight different cross-heads, and opposite the item of cross-heads you may find only five items reported, but there is no reason why the full lists should not be filed. The weights are as follows:

WEIGHTS (IN POUNDS) OF DETAIL PARTS OF LOCOMOTIVES.

ORIGINAL LISTS AS FURNISHED BY THE MAKERS (SLIGHTLY MODIFIED TO SECURE UNIFORMITY.)

SIMPLE FOUR-WHEEL SWITCHER BUILT FOR THE HARRISBURG PIPE & PIPE BENDING COMPANY BY THE BALDWIN LOCOMOTIVE WORKS.

SPECIFICATIONS.

Cylinders, diameter and stroke	15″ x 24″
Drivers, diameter	44″
Weight, in working order	67,900

WEIGHTS.

Driving wheels and axle, front, pair	5,690
Driving wheels and axle, main, pair	6,300
Driving box, one	208
Driving box, spring, one	158
Cylinders, pair	4,985
Cylinders, head, front	118
Cylinders, head, back	221
Steam chest cover	127
Steam chest cap	228
Valve	78
Frame, one	2,400
Boiler, without tubes	12,750
Cab, wooden (ash)	756
Driving axle, one	750
Main rod, complete	283
Side rod	230
Crosshead	181
Piston, one	170

TANDEM-COMPOUND DECAPOD BUILT FOR THE A. T. & S. F. RY. BY THE BALDWIN LOCOMOTIVE WORKS.

SPECIFICATIONS.

Cylinders, diameter and stroke	19″ & 32″ x 32″
Drivers, diameter	57″
Weight, in working order	267,800

WEIGHTS.

Driving wheels, on axle, front and back, pair	7,475
Driving wheels, on axle, intermediate, front and back, pair	8,055
Driving wheels, on axle, main, pair	9,375
Driving box, main	512
Driving box, others, each	444
Engine truck, without wheels, axles, or boxes	4,500
Engine truck, boxes, each	230
Engine truck, wheels, pair, on axle	2,080
Equalizing beam	160
Frames, each	8,400
Foot plate, front	415
Foot plate, back	910
Boiler, without tubes	43,000
Cab, steel	2,690
Axle, main	1,875
Axles, others, each	1,520
Crosshead	431
Piston and rod	1,075
Main rod (one)	1,030
Side rods, complete for one side	1,370
Cylinders, one (tandem compound, saddle separate)	10,160
Saddle	7,100

TEN-WHEEL ENGINES BUILT FOR THE C. C. C. & ST. L. RY. BY THE BALDWIN LOCOMOTIVE WORKS.

SPECIFICATIONS.	Simple.	Vauclain 4-cylinder compound.
Cylinders, diameter and stroke	20″ x 28″	15½″ & 26″ x 28″
Drivers, diameter	78″	78″
Weight, in working order	175,000	187,000

WEIGHTS

[illegible] complete without tubes	31,550	32,000
[illegible] complete set	13,110	13,110
[illegible] complete set	120	149
[illegible]	327	397

WEIGHTS.	Simple.	Vauclain 4-cylinder compound.
Tee pipe, in smoke box	176	194
Dry pipe	328	328
Stand pipe	146	146
Throttle box and valve	122	122
Exhaust pipe	171	171
Smoke stack	318	318
Sand box	515	515
Bell and stand	212	212
Cab	1,478	1,478
Injector, Monitor No. 10 (P. R. R. style)	95	95
Grates and bearers, set	2,235	2,235
Ash pan	1,700	1,700
Frames, complete set	10,800	11,000
Foot plate	995	995
Throat sheet crosstie	190	190
Guide yoke	655	668
Pilot	2,470	2,470
Bumper beam	530	570
Cylinder	5,400	6,950
Cylinder head, back	403	585
Cylinder head, front	232	480
Piston and rod, h. p.	435	335
Piston and rod, l. p.	...	545
Crosshead	281	533
Guide bar, top	267	1,054
Guide bar, bottom	214	...
Steam chest	194	...
Steam chest cover	75	...
Steam chest balance plate	395	...
Steam chest casing	74	...
Valve	178	211
Link, complete (with hanger)	125	125
Link, intermediate rod	128	128
Eccentric	132	132
Eccentric, strap	238	238
Eccentric, rod	56	56
Rocker arm	284	...
Rocker box	297	...
Rocker arm, box and shaft, complete	...	480
Reverse shaft	346	346
Reverse lever	82	82
Reverse lever, quadrant	30	30
Driving wheel center, main	...	2,909

WEIGHTS.	Simple.	Vauclain 4-cylinder compound.
Driving wheel center, front and back	...	2,449
Driving axle, main	1,265	1,265
Driving axle, front and back	1,265	1,265
Crank pin, main	218	218
Crank pin, front and back, each	96	96
Driver brake cylinder	341	341
Driver brake bell crank	356	356
Driver brake head and shoe	99	99
Driver brake beam	370	370
Driving tire, blind	1,183	1,183
Driving tire, flanged	1,300	1,300
Driving box, complete	470	470
Driving box shoe	32	32
Driving box wedge	49	49
Driving spring	345	345
Driving spring seat	76	76
Driving spring hangers, set	1,470	1,470
Drivng spring, large equalizer	157	157
Driving spring, small equalizer	127	127
Driving spring, equalizer stands	224	224
Air pump, Westinghouse, 9½″	544	544
Air drum	300	300
Engine truck, complete	9,500	9,645
Engine truck wheels, pair, on axle	2,460	2,460
Engine truck box, complete	720	720
Engine truck spring	235	310
Valve yoke	90	...
Valve rod and pin	66	28
Main rod, complete	543	801
Side rod, front, complete	259	259
Side rod, back, complete	319	319
Valve	178	211
Tender tank	13,680	13,680
Tender truck, complete	9,060	9,060
Tender, complete	48,900	48,900
Bell	97	97
Smoke box front	...	554

ENGINES BUILT FOR VARIOUS ROADS BY THE AMERICAN LOCOMOTIVE COMPANY.

SPECIFICATIONS.

Road	Vandalia Line.	N. Y. C.	N. Y. C.	A. T. & S. F.
Type of engine	8-Wheel	10-Wheel	Atlantic	Tand.Comp. Decapod.
Cylinders, diam. and stroke	20″ × 26″	20″ × 28″	20½″ × 26″	17½″ & 30″ × 34″
Drivers, diam	78″	70″	79″	57″
Weight, in working order	132,000	165,000	176,000	260,000

WEIGHTS.

Boiler (with tubes)	34,100	44,700	45,200	66,313
Bell, complete	218	197	200	......
Cylinder, h.p. (with saddle)	4,330	5,225	5,215	6,080
" l.p. " "	......	......	......	15,800
Cylinder head, front	215	250	261	200
" " intermediate	......	......	......	350
" " back	352	336	432	650
Cab	1,200	1,200	1,520	2,600
" material	wood	wood	wood	steel
Crosshead	155	145	295	437
Crank pin, main	123	195	216	328
" " intermediate	......	......	......	93
" " "	......	......	......	93
" " front	......	75	74	71
" " back	58	75	......	71
Dome cap	123	123	130	150
" finish	154	173	150	200
Driving wheel center, main	2,357	2,155	2,520	2,800
" " " interm'te	......	......	......	2,350
" " " front	......	1,700	2,200	2,012
" " " back	2,185	1,700	......	2,012
Driving axle, main	1,205	1,232	1,395	1,650
" " intermediate	......	......	......	1,300
" " front	......	1,177	1,395	1,300
" " back	1,205	1,177	......	1,300
Driving box, main	655	495	472	557
" " intermediate	......	......	......	477
" " front	......	495	472	477
" " back	655	495	......	477
Drawbar	290	274	250	300
Engine truck, complete	9,370	9,200	10,250	5,000
" " wheel	1,912	1,752	2,100	800
" " axle	516	563	620	742
" " box	221	221	221	300
Eccentric	241	118	112	212
" strap	143	150	160	225
Frames, set, complete	8,350	11,488	12,360	21,200
Frame filling	510	100	......	910
Fire brick	......	700	1,245	......

WEIGHTS.

Guides, full set	1,036	1,188	1,066	......
Guide yoke	296	577	662	......
Link	148	135	156	......
Piston, h.p.	400	420	468	......
" h.p. and l.p. combined	......	......	......	1,119
Reverse lever	85	75	140	......
" shaft	326	274	258	......
Rod, main	488	570	680	842
" intermediate	......	......	......	661
" "	......	......	......	261
" front	......	286	280	167
" back	280	226	......	167
Rock shaft	226	256	174	300
Running boards, set	......	......	1,114	......
Safety valve chimney	248	140	170	200
Sand box	565	500	725	850
Smoke stack	532	200	259	600
Spring, driving	294	250	339	220
" engine truck	236	201	203	387
" trailing "	......	......	436	......
Steam chest	344	238	......	......
" " cover { including bal. plate..	400	350	194	240
Steam pipe (one)	350	350	350	500
Tire, driving wheel, main	1,614	1,393	1,510	1,016
" " " interm'te	......	......	.....	1,016
" " " front	.....	1,330	1,510	1,016
" " " back	1,614	1,330	......	1,016
Throttle	280	273	290	300
Trailing wheel, center	......	......	845	......
" " tire	....	......	1,378	......
" axle	......	......	1,460	.....
" " box	......	......	500	......

THE PRESIDENT: Gentlemen, we have with us Mr. J. N. Dickey, a member of the New York State Railroad Commission, who will address us.

MR. DICKEY: Mr. President and Gentlemen of the Association,— My coming here was so entirely unexpected that it was necessary for me to jot down the few words I will say to you. Therefore, if you will pardon me for reading my brief speech, I will detain you for but only a few minutes.

The Governor of this State has requested me to extend a hearty welcome to you on his behalf, and to say that he is very glad that you have again chosen this ideal spot as the place for your annual meeting. As one of the Railroad Commissioners, I wish, on behalf of the Board, to supplement the welcome of the Governor by say-

ing that the Board is also pleased to have this distinguished and able body of men assemble in our State, and hope they will see their way clear to come again and again. As a citizen of this commonwealth, I am pleased to meet with you gentlemen whose ingenuity and ability have kept apace with the tremendous increase in traffic, at the same time permitting us to travel in safety and comfort. It is probable that you have met and surmounted more difficult problems in the last five years than were encountered during the preceding twenty-five years. I am not here, gentlemen, to attempt to instruct you in any detail of your profession, and do not wish to interfere with the orderly procedure of your business I simply desire to wish for your Association a successful and profitable meeting; that it will be a pleasant one is already assured by the fact that you have with you so many of God's best gifts to man. Wishing for you all brightening skies, good health and a safe return to your respective homes at the conclusion of your deliberations, I thank you again on behalf of the Governor and the Board I represent for the honor you have conferred upon us by again visiting the Empire State.

THE PRESIDENT: Mr. Dickey, on behalf of the Association, I want to thank you and also the Governor for your having made this visit to us and giving us this hearty welcome. We appreciate it. We hope to continue meeting here as you suggest, and on some occasion to have the Governor with us.

The next business in order will be further discussion of the topical question which was under consideration when the meeting adjourned yesterday: "Grinding as a Method of Finishing Piston Rods and Crank Pins." One of the members has suggested that Mr. Norton, who manufactures a grinding tool, be given the privilege of the floor. What is your pleasure.

MR. SINCLAIR: I move that Mr. Norton be given the privilege of the floor.

Motion seconded and carried.

MR. CHARLES H. NORTON (Norton Grinding Company, Worcester, Massachusetts): I do not know the drift of what has been said about this matter, as I was not here during the discussion yesterday, and I am a little at loss to know what to say to you. I do not want to work an advertisement on you. I can say that the

improvement in grinding wheels within the last two years has been very marked, and what three years ago was called a good grinding wheel would not now be considered worth very much, in this particular line of work. Perhaps it is due to the discovery of abrasives and different methods of combining them together in wheels that has made it possible to make heavier grinding machines commercially practicable. As you know, there are a number of artificial abrasives made in various parts of the world that were not known three or four years ago. For instance, artificial corundum is made at Niagara Falls that has the same chemical properties as nature's corundum — that is, the microscopic crystals of the ruby and sapphire — it is made by the carload. It seems funny to think of rubies and sapphires made by carloads — the crystals are not the jewels, but they are chemically the same as the jewel crystals. They are shipped to us at Worcester, where we crush them into grains. We are enabled to control the raw material and get a practically pure corundum — about ninety per cent pure crystal. It is due to that, more than anything else, we are able to-day to obtain such satisfactory results from grinding machines.

It is practical, with the modern machines and wheels, to remove one cubic inch per minute from soft steel.

If you wish to find the saving by grinding, find the cubic inches of steel that remain on the roughly turned work, and you have the number of minutes required to remove the material. To this add about three to four minutes for each twelve inches of length for the finishing. When work is turned when roughing to about 1-32 inch above the finish size, and with a very coarse feed, the saving by grinding is large.

The improvement has been in the last few years in putting into cylindrical grinding machines more of the machine-tool feature rather than the refining tool-making feature, so that to-day we have grinding machines that are very powerful, compared with according to the nature of the work to be done. We are grinding machines that carry six thousand pounds on centers for some heavy steamboat piston rods for some people on the Clyde, in Scotland.

The time saving in grinding becomes very large when you have the coöperation of the lathe department. We are now making the

lathe a roughing tool; and if you can have the coöperation of the lathe men in your various works, you can make large savings by grinding.

The grinding machine of to-day is a heavy machine, with plenty of pig iron in it and heavy steel spindles; where four years ago a grinding machine that carried a 12 or 14 inch wheel, possibly an 18-inch wheel, with the spindle weighing perhaps thirty pounds by itself, was considered heavy enough, to-day a machine for doing that same work has a spindle weighing one hundred pounds, a wheel 24 inches in diameter, 2, 3 or 4 inches thick, according to the nature of the work to be done. We are grinding piston rods to-day with wheels 4 inches thick and advance along the work 4 inches to every revolution of the rod during the roughing operation. Boiled down, the idea of the grinding machine to-day is to put more money and material into the machine and more power into the shortest space of time, and save labor.

On motion, the discussion was closed.

THE PRESIDENT: We will now take up the topic, "New Tool Steel and Its Effects on Shop Practice," and we will ask Mr. S. K. Dickerson, of the Lake Shore road, to open the discussion.

MR. DICKERSON: I do not know that I can add very much to what has been published on this question, as it has been quite freely discussed through the technical journals. We assume that the "new tool steel" refers to the high-speed steel, and in this connection a series of experiments were conducted at the Collinwood shops of the Lake Shore Railway Company. We at first began a series of comparative tests with a number of kinds of "high-speed" steel, but abandoned this before any particular results were obtained, concluding we should take one brand that had shown fair results and determine its possibilities and comparison with the former tool steels used and then, after sufficient data have been secured, to make a comparative test of several brands of "high-speed" steel. The material used for these tests (i. e., with the one brand of "high-speed" steel) was old steel locomotive driving axles, wrought iron and cast iron.

The question of feed, depth of cut and speeds were the principal factors to be considered. The feed and depth of cut are the factors that affect the speeds. In the finishing of most jobs in loco-

motive work, the feed is the principal factor, as the depth of cut does not usually vary greatly. In our experiments all tools were ground in a universal tool grinder to insure accuracy as to the angles, one-tenth of an inch lateral feed was adopted, as a coarser feed was found in many cases to be too severe, and a finer feed is required in a number of cases, of course, depending upon the work to be finished, although we did find that a coarser feed and slow speed in a number of cases would remove more material in a given time. A water jet was used with about five or six pounds pressure at the nozzle, which was a tube, the end of which was directed upward toward the point of the tool at an angle of about forty-five degrees, in order that the jet might reach as near the cutting edge of the tool as possible and avoid splashing the water; we also found that this had the greatest cooling effect on the tool. It was found, however, that the maximum cutting speed did not vary much either with or without dry tools, but a tool-cutting axle steel and run dry with a 3-16 inch depth of cut and 1-10 inch of feed, speed fifty feet per minute, would burn up in less than a minute, caused by the side clearance wearing away; it would run at the same speed, lateral feed, and depth of cut, with the water jet for from twelve to fifteen minutes. The chips or shavings in either case were of a deep blue.

A tool that will burn in ten to fifteen minutes, running dry, will run and do excellent work for over an hour when supplied with water jet as indicated above. At speeds of about forty-five feet per minute the body of the tool will usually conduct the heat away from the edge of the tool rapidly enough, but as the speed increases the temperature of the cutting edge of the tool rises so rapidly that the tool is soon weakened and spoiled. Tools ground with less side rake would last somewhat longer than those with a greater angle, and also take more power to remove the same amount of metal in a given time.

Tools for axle steel and wrought iron were ground with twenty-five degrees side rake, ten degrees end rake and eight degrees clearance. The most efficient depth of cut for all materials can not be answered definitely with the data at hand.

It was found that a flat-topped tool was worn deeply into the top, even with the water jet in use, and the chips removed were of a deep blue. When ground with a thinner cutting edge the chips

were not discolored and the tool worn but very little. With a continuous cut, and water jet on axle steel, it was found that it was perfectly safe to use an angle of thirty-five degrees side rake, cutting forty feet per minute, but an angle of twenty-five degrees is recommended because of cuts necessarily being intermittent, and with an angle of thirty-five degrees the tools are liable to become nicked, and this will cause overheating.

For cast-iron roughing tools the angles are recommended as follows: Side rake, fifteen degrees; end rake, ten degrees; clearance, eight degrees. Speeds on wrought iron, with 1-10 inch lateral feed and 3-16 inch depth of cut, vary from thirty-five to eighty feet per minute, according to the quality of the iron, as sometimes a little slag or foreign substance will ruin the tool at once.

Cutting-off tools will stand a speed of forty feet per minute, but the feed should be from 1-100 to 3-100 inch, depending on the material. High speed and fine feed prolong the life of the tools.

It was found with the different "high-speed" steels tested that some were much better adapted to certain classes of work than others; some doing very much better work where the depth of material to be removed was necessarily slight, as in boring locomotive tires, while others were very much better for turning locomotive tires when the cuts were heavy.

Usually a coarse feed with a slower speed will remove more metal in a given time than a finer feed and high speed, even where the power of the machine limits the depth of cut possible with a coarse feed, and that a very much higher speed for a given depth of cut may be obtained with a fine feed than with a coarse one, but the increase in speed does not compensate for the decrease in the cross-section of the cut.

It was found, on closing out the experiments, that several machines could not stand enough to get the full amount of work from the "high-speed" steels. One trouble we experienced at first was that the tool dresser did not heat the steel to near as high a temperature as should be done. In fact, we found it was next to impossible to "burn" these "high-speed" steels. Better results were obtained by heating to an almost welding heat.

In this connection we might also state that extreme care should

be taken to heat these high-speed steels very slowly. It was found that while these high-speed steels were mostly "air-hardening," that a considerably better tool can be had by heating them to an almost welding heat and dipping in oil. In some cases very fine cracks were observed, but they did no harm, and for all ordinary work the life of the tools was considerably prolonged. The usual time for boring 56-inch tires is from eighteen to twenty-five minutes (this does not include chucking), and at from thirty-six to forty-two feet cutting speed. We have bored fourteen of these tires (roughing) with one tool without regrinding. Turning tires is done at from eighteen to twenty-five feet per minute, depending on amount of material to be removed. We finish 21-inch cast-iron solid piston heads in two hours (including the chucking). This includes the taper fit for the rod, grooving for the packing rings and counterboring for the nut on the end of the piston rod. For stock, a light, finishing cut on the outside diameter is left for machining, to suit the diameter of cylinder for which it is to be used.

Light, finishing cuts on cast iron may be run safely (using oil-hardened tools) at speeds of eighty-five feet per minute. If much scale is to be cut (in roughing cuts), forty feet per minute is as high a speed as can be run with safety. With little scale and a fair machining iron, forty-five to fifty-five feet per minute is a safe limit.

Measurements of power consumed show that a roughing tool working on cast iron absorbs only about fifty per cent as much power as a tool cutting clean wrought iron, both tools, of course, being ground to suit the material to be worked on. We do not believe that the output of the shops will be increased on account of the "high speed" directly as it will from the fact that the "high-speed" steels have induced a very much closer supervision and awakened more interest in the work, etc. It was found on a considerable number of jobs that it takes a longer time to chuck the work than to machine it after being chucked. This fact will lead to the invention of special chucking devices for work that is duplicated and the machines that are found inadequate will be strengthened in the weak parts in order to be able to use the "high-speed" steel to the full limit in as many cases as possible.

Following is a tabulation of the principal results of tests:

Material.	Form of Tool.	Angle Degrees. Side Rake.	Angle Degrees. End Rake.	Angle Degrees. Clearance.	Speed per Minute.	Feed, Inches per Revolution.
Axle steel....	Roughing...	25	10	8	35 to 45	.10
Wrought iron.	Roughing...	25	10	8	35 to 80	.10
Cast iron....	Roughing ..	15	10	8	45 to 55	.10
Cast iron....	Cutting off..	0	0	8	35 to 40	.01 to .03

MR. C. E. SLAYTON; I should like to ask if any one has discovered a tool steel which will take light cuts off a tire, the outside of a worn tire, and go through the hard spots?

MR. T. H. SYMINGTON: Mr. Dickerson refers to the difficulty of manipulating some of the high-speed cutting steels. We have had a great deal of trouble in getting steel for some work we are doing now, and have tried nearly all the various steels, and a difficulty we have found, which is greater than that of heating it slowly, is to get it hot enough. We have bought very high-priced steels and we discovered, accidentally, that if we would heat the steel very hot, even so that you can burn it, we would obtain infinitely better results. Many people have told me they have not had good results out of the new high-speed steels, and I think that is the principal trouble. The man at the forge is in the habit of heating steel to cherry red, or a little more, and is afraid of burning it. The steel I have in mind gives no results unless you almost burn it and get it as hot as possible.

MR. J. F. DEEMS: I would say one word on that line. Some time ago I happened to be interested in a rather extensive use of high-grade steels, and an expert was employed in handling the steel and tempering it. The steel was heated to such a high degree that when the air-blast struck it, it would flow, and unless the man did that he did not consider he would get a good tool, which corroborates what Mr. Symington said. I have noticed, on a number of occasions, when this man put the blast on the hot steel, it would flow right out, and that was what he wanted in order to get the proper temper.

MR. W. B. LEACH: I would like to ask the gentleman who opened this subject what are the average cutting speeds that can

be made when using high-speed steels in machining the various parts of locomotives that we are required to handle in railroad shops, such as steel driving-wheel centers, turning and boring driving tires, planing iron and steel castings, etc.?

MR. DICKERSON: We use on boring tires about 38 or 40 feet a minute, possibly 42. For turning tires the speeds have to vary with the amount of metal removed; we run from 18, probably less than that for heavy cuts on turning tires, to 25 feet. The speed, of course, must vary with the feed in a certain sense.

I might add that our experience has been just about as stated by Mr. Deems and Mr. Symington — that we had trouble at first on account of the smiths being really afraid to heat the steel hot enough.

MR. QUEREAU: We have had some experience with this matter, but it has not been extensive enough to give any exact data, yet there are certain general principles that we have worked out, and which we are using. Last fall we made an extensive series of experiments on six makes of special high-speed steel, and what I am about to say applies to them in general, although, of course, more specifically to the better grades. We decided that we could, in our repair shop, increase the output of our machines, on which high-speed steel was applicable, about fifty per cent. I am inclined to think the percentage is low rather than high. We found we got the greatest improvement in turning tires — I mean tires which had been in service, in boring out tires and fitting them to the centers, and on steel axles; in other words, that the greatest benefit to be had was on steel of that nature and wrought iron. On cast iron the advantages were comparatively slight over the ordinary air-hardening steel. We got the least advantages from the high-speed steels where the tools were comparatively light, as on parting tools; in fact, there we fear we have discovered no decided advantage in the high-speed steels for parting tools, or for such tools as one would use on piston heads in scoring. In boring tire we run from about thirty-eight to forty-two feet per minute; we use two tools, one roughing and one finishing tool, and finish the boring on one operation. On cast iron we discovered no particular benefit. On brass lathes there was no particular benefit, and I believe we are wise in introducing the

use of these special steels only as experience warrants. For turning tires after they have been in service there is no doubt we make a decided gain. In fitting steel axles we make a decided gain, and on our wrought iron, where the lathes will stand them, there is a decided gain. But so far, in cast iron, there seems to be very little advantage, and very little advantage in any material where the tool is comparatively light. In other words, the tool must be of considerable section, not only because the material is quite brittle, but also to take away the heat which is, of course, what determines the life of the cutting edge.

PROFESSOR HIBBARD: I was considerably impressed by what the opening speaker said regarding the fact that in his experience the chucking of a piece of work often took more time than the cutting of it, and it occurred to me that the practice followed in some shops might very well be followed in all, namely, the practice of getting out an operation sheet by the draughting-room in consultation with the shop foreman or foremen. The operation sheet means that if a crosshead is to have work done upon it, that the draughtsman and the shop foreman will consult together as to the proper sequence of the different operations and also with regard to the proper chucks or vises or templates or arbors, etc., that are to be used and an operation sheet is got out in the draughting-room as a result of the conference, which specifies the various operations to be carried on and the sorts of templates and chucks and other parts to be employed and where they may be found. In other words, it would seem that the increase in the speed of cutting, the decrease in time of tool cutting, calls for a studying of the other side of the operation, namely, the handling of the chuck or jig or whatever is used, to cut down the other portion of the time, and that that side of the study can very properly be made by the draughtsman and the shop foreman. We know that in any manufacturing plant, if one department is getting its work speeded up so that it is rather getting out of work, where another department finds itself getting behind in its work, then the attention of the management is paid to the facilitating of the work in the slower department and this same idea on this smaller scale I think might very well be carried out.

Partly in this connection I beg to call attention of this Asso-

ciation to the magnificent paper written by F. W. Taylor entitled, "Shop Management," which, with the related papers by Mr. Day and Mr. Gantt, were discussed in a meeting of our sister society of Mechanical Engineers yesterday afternoon, Mr. Taylor's specialty being upon the time study of the cost of operation, and his method of conducting operations involves the use of an instruction sheet which is put into the hands of a machinist, telling him at what speeds to cut and other like information, similar to the operation sheet that I have just mentioned, and I am inclined to think that if the members of the Association who were not fortunate enough to attend that discussion yesterday afternoon, or who may not have read the original paper of some 126 pages in length, if they would read that paper in the Proceedings of the Mechanical Engineers, it would be an immense assistance in the proper use of the new tool steels and of the new tools.

MR. JOHN PLAYER: This discussion has been confined, as I understand it, mostly to revolving tools, such as lathes and boring mills, and I would like to have a little experience regarding these high-speed steels upon reciprocating tools, planers, slotters and shapers, and more especially with regard to cast steel.

MR. S. W. MILLER: I have had very little experience with this high-speed steel, but I have one case in mind where we had a lot of driving-box shoes to plane for an engine that was wanted in a very great hurry, and it happened, as with a good many other railroads, we were purchasing our castings from a local foundry. The quality of the metal was not what was desirable by any means — in fact, it was so hard it was almost impossible to make any impression upon it. We tried to plane them with a mushet tool and it was absolutely out of the question. I had in my office a piece of one of these high-speed steels and we succeeded in planing all those shoes, grinding the tool only twice. One other case that came to my attention was the use of one of these on a turret lathe in which, of course, the work was wrought iron and flooded with oil. The piece in the chuck was run at the rate of three hundred feet a minute and the speed was so high, and the heat generated so intense, that there was a stream of sparks coming from the end of the tool in the middle of the oil. It did not, however, harm the tool.

Mr. H. H. Vaughan: I think the introduction of this high-speed steel is, without doubt, about the most important thing that has occurred in machine-tool practice for a number of years, but its importance is not entirely due to the fact that it enables cuts to be taken at a far higher speed than we used to be able to, but to the fact that it has wakened everybody up. It has made us look into this question of what can be done. We are all interested, with each particular steel, in seeing at what speed a cut can be taken and great deal of the improvement that is now being obtained could have been obtained before if things had been investigated to the same extent with the older steels. I do not mean that the new steels are not better than the old ones, but that the introduction of these steels has given us a general waking up. With this waking up, of course, has come the consideration of several things. We have heard several speakers talk about the machines not being up to the work. This steel is going to force us to investigate these machines. We are going to know more about them, and we shall find certain tools inadequate for the work they are supposed to do.

Another thing brought up, and to which Mr. Dickerson refers, and which I believe to be of considerable importance, is how a cut should be taken in order to get the metal off most quickly. We have been carrying out quite an extensive series of tests, the results of which Mr. Dickerson gave you, on the method of taking cuts with a constant feed but at different depths of cuts, namely, 1/8, 1/4 and 3/8 inch cuts, and then taking another series at a different feed and with the same cuts and so on, making feed varying from 1-20 up to about 1/8, and cuts varying from 1/8 to 3/8, in each case attempting to speed the tool up to a point where it was destroyed in a given length of time. Those results have led, as Mr. Dickerson said, to the conclusion that you should take a heavy feed, but that the depth of cut is more important than the amount of the feed, because the speed at which you can run the work is, to a certain extent, independent of the cut, but is more dependent on the feed. I think that is very important as showing in what direction we should proceed with old tools, weak tools, to try to utilize these steels. It shows we should begin to take feeds in proportion to what the tool will stand and speed the tool up accordingly. I believe there is room for a great deal of work in

that respect, to see how the old tools in our shops can be utilized to get the work out.

We are getting down better in this cutting business and endeavoring to get it down finer and finer, but I think we should pay particular attention to the point that Mr. Dickerson mentioned, of the chucking occasionally taking more time than the cut. That is a thing that almost naturally follows from the attention that is given to the subject. The first thing we try to do is to get the metal removed at the maximum rate and we are not going to find that the increase in output is anything like proportionate to the increase in speed in the removal of metal. In the figures Mr. Dickerson prepared for me on the question of grinding, he ascertained our average time of turning piston rod outside of the grinding. The time taken to take the roughing cut over the parallel portion of the rod is twelve minutes, and the time to do the lathe work is one hour and twelve minutes; that is to say, there is an hour spent in cutting a little thread on the end and facing the end and centering it, and only twelve minutes spent in the real heavy metal cutting. I think that this jolt we have received, calling our attention to these losses, is going to be really of more value in making us look after things and getting at them in a logical manner and following the thing to its limit as to why we are taking as long as we are in certain work, than the actual change in the cutting speed.

I do not think we are going to see machine tools developed to the extent of what I might call the limit of this cutting-tool business. It is going to be almost more expensive than is warranted by the slight change in the total time taken on the work. If a piece of work takes, say, twenty minutes for the actual removal of the heavy metal, and the total time is an hour and a half or two hours, including a number of miscellaneous movements, it is not going to pay to spend much money to cut the twenty minutes down to fifteen. We still have the hour and a half on the miscellaneous operation. It will pay to spend more money to get up jigs and things to cut down the miscellaneous time, than it does to spend a great deal of money for a special tool which only reduces a portion of the time by a small percentage, and this steel tool proposition appears to me to be going to lead us more and more up to the man question.

In looking after the steel, we must consider the man. The shorter the time it takes to remove the metal and the longer the time it takes to do the miscellaneous work, the more important the man is going to be, and the greater showing a good man is going to make over the poor one. The machinist's trade, with the introduction of this steel, will, I think, begin to lose that portion of it which depended on knowing how fast a machine can cut. That is going to be done for him, and it will make more important his knowledge of how to set up his work and manipulate the tool quickly, and avoid these miscellaneous losses which are rapidly becoming a more important part of the total time of production.

MR. D. VAN ALSTYNE: Can Mr. Vaughan say about what saving is practicable, with the use of high-speed steel in regular service?

MR. VAUGHAN: I could not tell you. We could get some figures on occasional jobs, like boring tires. Six or eight months ago we were boring tires, 60-inch tires, at the rate of three and a half hours a pair. Ten or twelve tires we would consider a good day's work. The actual time of boring is eighteen to twenty minutes. The rest of the time is occupied in setting up and getting the crane over to get the tire into place, etc. We have to look after the lost time in handling, more than the actual time in cutting. I do not suppose that if we had gone on boring tires at the rate of three and one-half hours per pair, we would have worried about ten minutes lost in crane service. When you run a tire through in twenty minutes, however, you begin to worry about ten or fifteen minutes being lost in handling the crane. On driving wheels there is probably an increase in output of two to one. You get the increase in output more on the big, straightforward jobs, of which there are really very few in a railroad shop, than on the small, miscellaneous jobs, in which the actual time of removal of the metal is comparatively small in comparison with the total time taken in the operation. I should say, as a broad estimate, that about fifty per cent increase in output, or thirty-three per cent reduction in cost, is about what you could expect to obtain, but I do not think that is the reduction we can obtain if we stop at the steel and do not follow the rest of the troubles.

MR. CLEMENT F. STREET: We have, in our shop at Cleveland,

been using high-speed steel for some time on both gray iron and steel castings, and have had very satisfactory results. We are able with this steel to cut steel castings at higher speeds and with heavier feeds than we formerly employed on gray iron with common tool steel. We have made some experiments in the use of high-speed steel in twist drills. This matter was brought to my attention by one of the members of this Association making the statement that he was able to use a high-speed twist drill for ten hours, running at double the speed of an ordinary drill, and do this without grinding. On the strength of this statement, we paid about $5 a piece for four 15-16-inch drills, made from high-speed steel, and put them in a multiple-spindle drill press in our shop, where we were drilling steel castings. We increased the speed at which the press had formerly been running, and, although it was guaranteed to pull four 1½-inch drills, after it had been running three or four hours it was heated up to a point which made it necessary to reduce the speed to the former rate. We were, therefore, able to obtain only very little better results with the high-speed than with the ordinary steel, and the result of the test was not altogether satisfactory. We expect in the near future to make further experiments, and believe that we shall be able to obtain satisfactory results with drills made from high-speed steel. It is, however, a question whether these will be sufficient to warrant us in paying the additional cost.

MR. DEEMS: Was it a representative of the high-speed steel who recommended its use?

MR. STREET: No, it was Mr. Sanderson.

MR. DEEMS: I took up the question of the twist drills some three or four years ago, with the idea of using high-speed steel, and all of the representatives of that kind of steel said it was not satisfactory to be used in a twist drill.

MR. STREET: Our information is that one of the manufacturers of twist drills is advocating the use of the high-speed steel for such drills.

MR. DEEMS: That is what I thought; there might have been changes made so that they would recommend it. Two years ago they said they would not recommend the high-speed steel for drilling purposes. We tried it, and it was not a success.

Mr. Street: The manufacturers from whom we bought some of our drills rather objected to making the drills. They said the reason for the objection was that it interfered with their regular business; that the steel was so difficult to handle it was out of their regular routine work, and they would much prefer not to make them. One of the other twist-drill manufacturers, however, has been soliciting the business. The manufacturer who objected to making the drills did not say they were impracticable.

Mr. William Forsyth: In reply to Mr. Deems I would say that in the Yarrow's works in England the high-speed drills are used and they are made by Firth, and the steel is called "Speedicut." They have made some careful experiments with the high-speed drills and find the improvement in the time required is about three to one. The English in that respect seem to be ahead of us in this country in the use of high-speed steel for twist drills.

Mr. Street: Do you know whether it was on cast steel or cast iron?

Mr. Forsyth: I understand it was on cast iron and wrought iron. The work is done on the heads which are used in the Yarrow boilers.

Mr. Street: One of the difficulties we had with the drills was in their breaking. We found they broke much more rapidly than the ordinary steel, but perhaps we were punishing them too hard. I would not want to put that down as absolutely against the twist drills, as we did not go far enough to determine whether they would stand up, as they should, without breaking.

Mr. David Holtz: I have tried drilling with the high-speed steel, and we have drilled through cast iron one inch thick in thirty-five seconds and wrought iron, dry, in forty-five seconds. It was an inch hole in both cases.

Mr. D. J. Redding: We have had some experience with high-speed steels, and use the high-speed steels to a considerable extent. Just to find out what could be done, we ran a 15-16-inch drill at the rate of 240 revolutions per minute and drilling six holes in cast iron at the rate of three inches to the minute without affecting the drill. Then we put a piece of 1½-inch wrought iron on the drill press, and drilled five holes through the 1½-inch

wrought iron at the rate of two inches a minute. On the fifth hole the high-speed drill commenced to weld with the wrought iron on the point. We took out the drill and tried one of our ordinary standard twist drills of the same size, made of good, ordinary steel, on the inch and a half plate, without changing speed, and it welded with the point when it got in three-quarters of an inch. The holes were bored dry and this probably represented extreme practice, but in ordinary service I think we are safe in saying that we can make an increase in the amount of metal removed of at least one hundred per cent. We are boring 44-inch tires with high-speed steel on an average of fourteen pairs in ten hours, chucking and boring complete. In one instance that I recall, we bored eight tires without changing the roughing tool. On turning tires we think that the speed limit is governed largely by the condition of the machine.

The ordinary driving-wheel tire lathe, after it is in service a while, has more or less lost motion between the teeth of the gears, and while you may have an average speed of fifteen or twenty feet per minute, the speed at the moment of the chattering, from one jump to the other, is very much higher than fifteen or twenty feet. If you could get a constantly driven speed on turning tires it would give a better showing. Much higher speed could probably be shown if the tire lathes were equipped with worm-screw driving mechanism, which should do away with chattering. The gentleman on my right raised the question as to what speed could be made in turning tires having hard spots, and asked if a tool steel had been found which would cut the hard spots. We find that the high-speed steel will cut through hard spots very much better than the old tool steels. As Mr. Vaughan has said, electrical control for tire lathes is a good thing, as it enables you to slow down while cutting through the hard spots, which are usually few in number, without losing much time on the entire operation.

Mr. E. W. Pratt: With regard to the last speaker's remarks on the tool chattering in the wheel lathe, I would like to ask Mr. Quereau or Mr. Dickerson if they do not have to take additional precautions in the use of their high-speed steel in turning tires mounted on wheel centers and axles. Do you have to use additional dogs or chucks on the back center or the face plate?

Mr. S. W. Miller: There is one point in this discussion that I do not think has been brought out as fully as it should be. We are all talking of the advantage of high-speed steel over other steels. The question of advantage is entirely a relative one. Have we in the past been getting the best results we could get out of the steels we have been using, or are the advantages we speak of the results we get from a proper application of the high-speed steel, compared with our previous practice, whether good or bad? I have had some personal experience in that connection, and in one case we increased the output nearly one hundred per cent, with the same steel as before, same men, same chucks, same material, in fact, all the conditions the same, simply by watching closely the methods of doing the work.

The President: Will Mr. Minshull give us the benefit of his experience with the steel, not mentioning names or make, but give us a comparison between the old steel and the new steel with steel-tired wheels?

Mr. P. H. Minshull: We turned two 42-inch steel-tired wheels, using the old style of steel on one wheel and the new style on the other. The old steel gave out when one-third of the tire was turned. The new steel completed its tire and finished the other wheel on which the old steel was first tried, and the new steel was good after the second wheel was finished. The chips were about equal.

Mr. Quereau: In answering Mr. Pratt's inquiry as to whether we had to strengthen the chucks or not in using high-speed steel for turning tires, I will say we did not strengthen the chuck, but did strengthen the fastenings, and we were enabled to reduce the chattering to the point we thought it ought to be reduced to. We are running from eighteen to twenty feet per minute in turning the tire.

At the expense of continuing the discussion a moment longer I want to say it seems to me that the point raised by Mr. Vaughan, as to the effect of high-speed steel in compelling us to look into the conditions and methods of handling work in the most expeditious and economical manner, can not be emphasized too strongly. Considerable has been said about boring driving-wheel tires. We have had an experience at West Albany in the use of the high-

speed steel by which the output of the mill for 44-inch and 53-inch tires was increased from five to an average of twenty-two in nine hours. That was brought to pass by increasing the force of laborers handling the tires to the machine, as well as the increase due to high-speed steel, necessitating, of course, an increase in the force of the helpers in handling the tire to the machine. I was going to say how much the force had been increased, but I will not undertake to do it. I am strongly impressed that advantages are going to come out of the use of high-speed steel, in leading us to investigate our present methods, more than is coming directly from the time saved by the use of the high-speed steel in any particular operation. That is something we can not place too much emphasis upon.

THE PRESIDENT: We will now take up the report on "Recent Improvements in Boiler Design." Mr. D. Van Alstyne, chairman of the committee, presented the following report:

REPORT OF COMMITTEE ON RECENT IMPROVEMENTS IN BOILER DESIGN.

To the Members of the American Master Mechanics' Association:

The Committee on "Recent Improvements in Boiler Design" decided to divide its report into two parts, Part I to describe recent boilers, both American and foreign, for different classes of service and for various kinds of fuel, and Part II to determine so far as possible how satisfactory recently built boilers are and what principal troubles are experienced with them.

PART I.

Progress in boiler design may be said to be along the lines, and in pursuit of, increased efficiency as a steam generator, rather than in perfection of constructive details which affect first cost and that of maintenance. Your committee, believing that a graphic representation would convey a clear conception of the present status of boiler construction, has selected some examples of the product of 1902-3 — both American and foreign — for the different classes of service, which embrace designs for bituminous, anthracite, and lignite coals, and also oil, for fuel. The accompanying table furnishes particulars of heating surface for each boiler, as well as other points that will make comparisons of interest.

For illustrations see Figs. 1 to 15.

The most prominent features of design to attract attention are those of heating surface and grate area. Professor Goss pretty nearly exhausted

the boiler-power question when he said: "The maintenance of pressure in the cylinders demands steam from the boiler, and the limit of cylinder work is reached when the boiler can no longer meet the demands made upon it." This is all fundamental, though recent, but is in strong contrast with the old order of things where cylinder dimensions alone signified a powerful engine.

The boiler of 1903 is designed with special reference to well-defined conditions, in which the horse-power involved is provided for by a heating surface and grate area, of proportions that are expected to unfailingly supply the cylinders. That these expectations are fully met is attested by the performance of the latest engines.

The wide fire box which is rapidly becoming recognized as a standard form of construction, is responsible for the extraordinary length of tubes on engines which, on the 4-6-2 type, reach a length of 20 feet in some cases, made necessary by placing the wide fire box at the rear of six-coupled 80-inch wheels. Foreign builders are regarding with favor the trailing truck design, since they gain a grate area impossible of attainment in the older form of passenger engines, and to this is due the appearance abroad of the 4-4-2 4-cylinder compounds of the Baden State Railway, with 42 square feet of grate, and others. The De Glehn 4-cylinder balanced compound is also of the 4-4-2 type, although it has not the fire box extending over frames, but the design of engine lends itself to such construction which will doubtless be seen on future engines of the De Glehn type.

A reference to the table herewith will show how extensive has become the tendency to increase heating surfaces for the new conditions, over those recommended in the report submitted to this Association in 1897. The ratio of fire-box heating surface to total as given therein was ten per cent. The large fire-box heating surfaces shown are five per cent and under in some instances, for which the enormous number of tubes is responsible. This is plainly evident in the Chicago & Alton 4-6-2 engine, which has the lowest percentage of fire box to tube surface among the passenger engines. This engine was designed for an especially exacting work which demands an unfailing boiler power. The New York Central 4-4-2 engine has demonstrated the necessity of a boiler with unlimited steaming capacity, in numerous performances with a total load of engine and train of more than 730 tons at speeds of over fifty-five miles an hour.

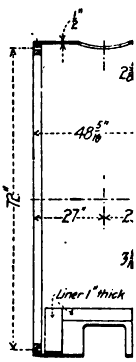
It will be noted that the foreign engines have a ratio of fire box to tube surface more nearly in harmony with the work of the committee referred to. The 4-4-2 De Glehn 4-cylinder balanced compound engine of the Northern Railway of France has made a record for development of a high horse-power on a very small heating surface, contending with 0.5 per cent grades at a speed of seventy-four miles an hour, with 295 tons of engine and train. More than 1,500 De Glehn engines are now in service. The 0-10-0 3-cylinder simple engine of the Great Eastern Railway has boiler proportions of the greatest magnitude of any of the foreign engines, having been designed for suburban passenger service in which stops are numerous, and with a gross load of 414 tons. This work requires the

engine to accelerate quickly, therefore the small wheels and large boiler, the latter feature being an innovation in English design.

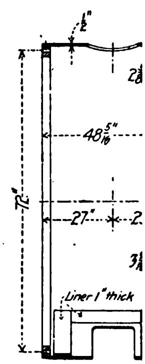
The London & Southwestern Railway has more than one hundred of the Drummond water-tube boilers in service, and it is stated that all locomotive boilers of this road are now being fitted with cross water tubes. Under this system, the fire-box heating surface is increased nearly one hundred per cent by means of the water tubes, and equals 30.8 per cent of the total. This would appear to be a practical illustration of the ancient proposition, that the higher the percentage of fire-box heating surface to total heating surface, the greater the evaporative efficiency of the boiler, a logic that remains to be controverted. A boiler of this character, but with water tubes in the fire box only, has been designed by Mr. Riegel of the American Locomotive Company. This system contemplates two nests of water tubes extending from center of crown sheet diagonally down to side water spaces, by which it is claimed to be possible to get over 1,800 square feet of efficient heating surface in the fire boxes of the larger types of engines, making a total heating surface of over 6,000 square feet. There is no doubt of the necessity of such a design, since fire boxes have about reached the limit of size, both from a clearance standpoint as well as that of operation. There is no record of any construction of this idea.

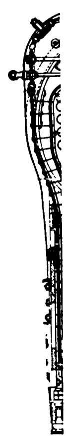
Superheating of steam is attracting considerable attention abroad, particularly on the Prussian State Railways, where seventy engines are fitted with the Schmidt system of superheating. In addition to these the Schmidt principle is in use on the Alsace-Lorraine State Railways, the Belgian State Railways, the Moscow-Kasau Railway, the Southern Railway of Italy, and the Munich Suburban Railway. In this country the same superheating device is in use on the Canadian Pacific, and the American Locomotive Company is now constructing another engine similarly equipped for the same road. It is understood that there are also five of these engines under construction by the Pennsylvania road. Very glowing accounts of the performance of Schmidt engines, by an American engineer who has recently returned from Europe, would imply that there were economics in superheating of steam for locomotives.

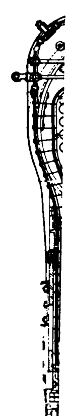
Even with the successful overcoming of resistance at continuous high speeds there is a question among some officials that, while we have ample heating surface, it may not be in the right place, or, in other words, it is possible that we have too much heating surface in the wrong place, that is, are not too many tubes used, and would not a boiler furnish an equivalent or a higher evaporation with a lesser number? There appears to be good reasons for questioning the efficiency of a multitude of tubes, among which are the following for reducing the number: A better circulation due to the wider spacing of centers; a reduction of liability to leakage, and longer life to tube sheet due to the greater section of material between holes. It is not apparent that there are any very serious difficulties to surmount in making tests that will demonstrate to what extent evaporation and cost of maintenance is affected by a wider spacing of tubes. Such experiments

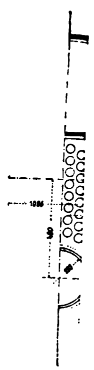


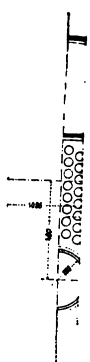
48 5/16"
27"
72"
Liner 1" thick


48 5/16"
72"
27"
Liner 1" thick









ıld definitely decide whether the practice of encroaching on circula-
ı space with tubes is conducive to an economical evaporation, and in
lition would no doubt incidentally furnish some needed light on the
:ct of a higher ratio of fire box to tube heating surface under the new
ıditions. Restricted water spaces around the fire box are well known
be inimical to a proper circulation, as well as dangerous to the sheets,
l the same effects are known to operate at the fire-box ends of tubes.
e wide fire box has shown a marked tendency to crack at the sides,
l as a remedy it is proposed to make the fire-box ring 4½ inches wide
some engines now under construction.

In bracing and staying there is little to be recorded as new. In
nt construction the welt type is said to be improved to an efficiency
ninety per cent of the solid plate, and welding of joints is said to be
isfactorily done, both on dome sheets and longitudinal joints, the latter,
wever, not continuous but at ends only.

The reason for the increase of heating surface being one of boiler
wer to meet the greater demands of the cylinders, it is plain that the
estion of design should have direct reference to the amount of water
ıporated by each square foot of heating surface per hour. If the heat-
; surface is designed for the work to be done, that is, on a horse-power
sis, then the problem becomes one of design for specific conditions. In
ıt case the facts entering into calculation are:

(1) Resistance to overcome.
(2) Horse-power required.
(3) Water consumption per horse-power hour.
(4) Water evaporated per square foot of heating surface per hour.
(5) Evaporative value of one pound of coal.
(6) Grate area to accord with calorific value of fuel.

This process has to do with actual values only, eliminating all factors
doubtful utility.

Your committee is under obligation to the technical press for courte-
s extended in the way of illustrations, among which are, the *American
gineer, Railroad Gazette, Locomotive Engineering* and *London Engi-
ering.*

PART II.

To obtain information for Part II a circular was sent out containing
ıumber of questions. Replies of special interest are quoted, preceded by
mbers, by which the roads replying to the circular are designated in this
port. (See Table No. 1.)

*Question No. 1. In general, what are the principal troubles you expe-
nce with large high-pressure boilers as compared with old low-pressure
ilers?*

Eleven roads having good water or good coal and water report very

little increase in boiler troubles, or not enough increase to be of serious consequence.

Sixteen roads having poor water or poor coal and water report large increase in leaks in shell, flues, mud rings, crown bolts, stay bolts, cracked sides, door, flue and throat sheets, and broken stay bolts.

Question No. 2. Please send drawing of your most successful boiler for heavy locomotives.

Some of the principal dimensions taken from blue-prints furnished are given in Table No. 1.

Question No. 3. What improvements do you contemplate making in future boilers as a result of your experience with modern high-pressure boilers?

Ten roads report no improvements are contemplated.

No. 2. Double rivet mud-ring corners.

No. 3. Improve suspension of boiler on frame, also increase depth of throat sheet and make grate level.

No. 6. A reduction in size of stay bolts and a closer spacing of them and crown bolts; widening of water space around fire box; rounder corners on mud ring; single fire box in wide-fire-box engines.

No. 8. Continuous side and crown sheet and sling crown bar or sling stays.

No. 9. Will substitute one fire door for two.

No. 11. Will use reduced center stay bolts to a large extent and use exceedingly soft grade of fire-box steel experimentally. Attempt to get builders to weld barrel seams at ends.

No. 14. Increased thickness of side sheets from 5-16 to 7-16 inch. Increased water space from 3½ inches to 4 inches at sides. Increase the distance 13-16 inch between flues, and flange the flue sheet.

No. 16. Larger diameter of flues and shorter flues than shown by blue-print.

No. 19. Increase inside radius of mud-ring corners. Increase height of dome. Decrease thickness of front flue sheet.

The only serious trouble with these boilers is leaky flues and that we do not know how to cure.

No. 21. Water space and flue spacing increased.

No. 23. Slope crown sheet ¾ inch per foot and support same by crown bars made of T-iron placed not less than 6 inches above crown sheet. We will also apply flexible stay bolts as follows: All bolts in throat sheet, three outside rows and three top rows in back head, and four outside and four top rows in side sheets.

No. 26. Bracing flue sheets and increasing thickness of side sheets where necessary.

No. 27. We are putting in flexible bolts.

Question No. 4. What horse-power per square foot of heating surface can you generate without overtaxing the boiler and causing it to give trouble?

Replies vary from .31 to .62, with an average of .41.

No. 3. Have dynamometer records of boilers of 2,926 square feet heating surface developing 1,060 horse-power (.36) and of boilers of 2,608 square feet heating surface developing 1,150 horse-power (.44).

No. 11. Can not say. No evidence that heating surface could not evaporate more water than it does at present if we could get the heat to it.

No. 25. Depends upon service. Boiler shown on drawing X 9300 will develop 1/3 horse-power per square foot easily in passenger high-speed service.

Question No. 5. How much more economical of coal are wide-fire-box boilers than narrow?

Most of the roads have no data.

No. 3. Little economy in use of wide fire boxes.

No. 5. In passenger engines not much difference. In freight engines the wide fire box is less economical.

No. 6. Have made no experiments, but judge about eight per cent more economy with wide fire box than narrow.

No. 7. Twenty per cent on passenger and forty per cent on freight, due to being able to use cheaper grade of fuel.

No. 14. Have made no tests, but would estimate five to ten per cent.

No. 16. Five to ten per cent saving, estimated from coal record.

No. 17. About ten per cent, estimated.

No. 19. Comparing engines which are quite similar, we find ten per cent economy in favor of wide fire boxes.

No. 20. Do not believe wide fire boxes more economical, but are very good steamers.

No. 21. No appreciable difference.

No. 22. Fuel tests on engines of about same type (except grate areas) over same division as follows (see Table No. 2).

Consolidation Mastodon type, 23 and 35 by 34 inch cylinders, 57-inch drivers.

Class F. C. with 35.3 square feet grate area.

Class F. D. with 54 square feet grate area.

14.8 per cent in favor of Class F. D.

Mogul type, Class E. D., 20 by 28, 62-inch drivers, 30.33 square feet heating surface.

Class E. F., Baldwin Compound, 15½ and 26 by 28 inches, 49.5 square feet grate.

19.9 per cent in favor of Class E. F.

(NOTE.— In first comparison engines exactly alike except grates.)

No. 24. Twenty per cent.

No. 26. About ten per cent where full tonnage is handled.

No. 27. Very much; we burn anthracite "buck."

Question No. 6. What is the maximum grate area which can be economically fired by one man?

Most of the replies give grate areas that are being fired economically and vary from 35 to 72 with an average of 50 for bituminous coal, and from 80 to 95 for anthracite coal.

No. 6. By saying 50 square feet I simply make a guess. I believe we have about reached the limit of the human stoker and what we want now is a mechanical stoker.

No. 9. Can not give satisfactory answer. There are so many factors involved, including strength and endurance of the man, the design of fire box and class of service.

No. 11. No data. Consider it more a question of a maximum amount of coal and maximum grate area, although limit is probably about 50 square feet for uniform covering.

No. 14. A grate 8 feet wide and 9 feet long should be economically fired by one man.

No. 15. I think we have reached the limit in grate area in our Central Atlantic type boilers.

No. 16. About 72 square feet.

No. 19. Apparently about 45 square feet for Illinois and Iowa coal.

No. 23. Do not think a grate area can be applied to a locomotive too large for one man. In my opinion we are getting our locomotives too large for economical operation with either one or two firemen.

No. 26. Not over 50 square feet.

No. 28. About 40 square feet for long medium-width fire boxes over frames, but with comparatively short wide fire boxes with two doors, the size of engine only should limit this.

Question No. 7. Do you find wide fire-box boilers more wasteful of coal than narrow, when standing idle under steam?

Fourteen roads say yes.

Three roads say no.

Others have no data or do not reply.

No. 12. Yes, more wasteful in proportion to grate area; 50-foot grate consumes 300 pounds per hour.

No. 22. [illegible] about [illegible] per cent increase. Amount of coal [illegible] 50 square-foot grate [illegible] about 150 to 300 pounds [illegible]

No. 28. [illegible] fire boxes.

[illegible] in the district

No. 2.

	Grains per gal.	Grains per gal.
Silica	1.25	1.25
Oxides of iron and alumina	.17	
Calcium sulphate	12.10	12.10
Calcium carbonate	7.04	7.04
Magnesium carbonate	4.50	4.50
Sodium chloride	.82	
Potassium chloride		
Organic matters (calculated)	.70	
	25.58	24.89
Hardness	15.00	

No. 3.

	Ellwood, Iowa. Grains per gal.	Average of all regular stations H. & D. Division. Grains per gal.
Oxides	.06	Undetermined.
Calcium carbonate	9.97	7.42
Calcium sulphate	1.67	14.97
Magnesium carbonate	6.37	9.62
Magnesium sulphate		2.77
Magnesium chloride		.20
Calcium nitrate		.20
Incrusting solids	18.07	35.18
Alkali carbonate		2.01
Alkali sulphate	2.33	10.82
Alkali chloride	.56	
Non-incrusting solids	2.88	12.83
Total	20.96	48.01

No. 5.

	Indianapolis. Grains per gal.	Collinsville. Grains per gal.
Solid residue	25.13	29.93
Incrusting solids	17.42	25.15

No. 6.

	Grains per gal.
Incrusting matter	9.61
Alkali	26.71
Sulphate lime	4.00
	40.32

		East Bethany. Grains per gal.	Groveland. Grains per gal.
No. 7.	Sodium chloride	.27	.48
	Potassium chloride	1.25	
	Potassium sulphate		.43
	Magnesium chloride	.89	
	Sodium sulphate		.12
	Calcium sulphate	3.91	1.86
	Calcium carbonate	9.79	4.82
	Magnesium carbonate	3.70	2.07
	Silica	.45	.41
	Iron and alumina	.08	.15
	Organic matter	5.39	1.03
	Total residue	25.73	11.37

		Typical foaming water west end of line. (Wyoming) Grains per gal.	Typical water east end of line. (Nebraska) Grains per gal.
No. 8.	Silica	4.18	3.24
	Oxides iron and aluminum	.47	.06
	Calcium carbonate	2.28	13.40
	Magnesium carbonate	.62	3.78
	Calcium sulphate	.37	
	Magnesium sulphate	.20	.44
	Sodium sulphate	46.19	10.49
	Sodium carbonate	2.85	
	Sodium chloride	1.40	1.20
	Organic matter	2.54	.92
	Incrusting matter	8.12	20.92
	Non-incrusting matter	52.98	10.61
		61.10	31.53

No. 9. About 15 grains incrusting solids per gallon.

		Lima. Grains per gal.
No. 11.	Oxides	.09
	Calcium carbonate	
	Calcium sulphate	30.11
	Calcium nitrate	
	Magnesium carbonate	13.37
	Magnesium sulphate	5.27
	Magnesium chloride	
	Incrusting solids	48.84

	Lima Grains per gal.
Alkali carbonate	
Alkali nitrate	
Alkali chloride	6.83
Alkali sulphate	.35
Non-incrusting solids	7.18
Total	56.02

No. 13. Appearance — clear.
Reaction — slightly acid.
Total solid residue, 21.87 grains per gallon.
Scale-forming solids, 21.11 grains per gallon.
Residue consists mainly of sulphate of calcium and magnesium. Small amount of chloride of sodium; trace of carbonate of calcium.
Character of water — corrosive.
The objectionable character of water is due not so much to the high per cent of scale-forming solids as to the fact that they are corrosive.

No. 14.

	Grains per gal.
Lime carbonate	3.66
Magnesium carbonate	10.18
Lime sulphate	15.03
Sodium chloride	7.31
Magnesium sulphate	Trace.
Oxide and silica	.30
Volatile and organic matter	4.42
Total solid	40.90
	28.87
	12.03

No. 16.

	Grains per gal.
Calcium carbonate	11.00
Magnesium	5.63
Sodium sulphate	1.66
Sodium chlorides	1.16
Dissolved carbonic acid	7.37
Silica	.48
Alkalinity	20.41
Suspended matter	.61
Incrusting solids	17.72
Non-incrusting solids	2.82

No. 19. Average about 18 grains incrusting solids per gallon and 21 grains total solids.

No. 21. Lake Erie water (100) parts per 100,000:

	Grains per gal.
Total solids	40.80
Organic and volatile solids	14.40
Fixed solids	26.40
Chlorine	1.00
Sulphates	3.98
Iron	Trace.
Total hardness	15.10
Temporary hardness	10.80
Permanent hardness	4.30
Reaction	Alkaline.
Valuation	75

No. 22.

	Excessive alkali as in western Arizona. Grains per gal.	Coast division of California. Grains per gal.
Carbonate lime	10.00	18.00
Sulphate lime	2.00	3.00
Carbonate magnesium	2.00	5.00
Sulphate magnesium	6.00	16.00
Silica, alumina and iron	2.00	2.00
Sulphate soda	10.00	8.00
Chloride soda	48.00	10.00
Total	78.00	62.00

No. 23. Average water on this line:

	Grains per gal.
Carbonate calcium	8.46
Carbonate magnesium	9.11
Sulphate calcium	16.54
Chloride magnesium	.63
Sodium	.78
Alumina	.26
Silica	.37

No. 24.

	Grains per gal.
Carbonated lime	24.03
Carbonate magnesium	12.23
Sulphate lime	.33
Chloride magnesium	16.20
Alkalis and chlorides	237.54

No. 25.

	Grains per gal.
Scale-forming solids	16.65
Soluble salts	3.10
Total solid residue	19.75

No. 26. About 40 grains scale-forming matter per gallon.

		Grains per gal.
No. 27.	Carbonate lime	.06
	Carbonate magnesium	1.82
	Sulphate lime	7.56
	Sulphate magnesium	Trace.
	Oxide, iron and alumina	Trace.
	Silica	.40
	Alkali chloride	.73
	Alkali sulphate	.53

Question No. 9. If you treat water for locomotive boilers, is it done before or after water enters boiler, and how?

Five roads reporting little or no boiler trouble do not treat water.

Five roads reporting little or no boiler trouble treat water in locomotive tenders or in station tanks.

Two roads reporting large amount of boiler trouble do not treat water.

Seven roads reporting large amount of boiler trouble treat water in locomotive tenders.

Seven roads reporting large amount of boiler trouble treat water in station tanks.

No. 23. Treating water by "Wefugo" process. Also using Talmadge device, which treats water by use of oil and frequent blowing out, after water enters boiler. Of the two processes, the Talmadge has so far worked the most successfully.

Question No. 10. How does the treatment affect fire-box and flue troubles?

Eight roads treating water in locomotive tanks report more or less decrease in formation of scale and decrease in leaky flues.

Two roads treating water in station tanks report largely decreased scale formation and boiler troubles.

Four roads treating water in station tanks report no noticeable effect, or not in use long enough to enable them to determine.

No. 3. (Soda ash in locomotive tenders.) Decidedly to advantage of fire box and flues so far as good service is concerned, when washing out and blowing off is properly done.

No. 5. (Soda ash in locomotive tenders.) Helps some by softening scale. No bad effects on flues or fire box.

No. 9. Soda ash is very beneficial with certain kinds of water in prevention of leaky flues and formation of scale. Have experimented with various compounds, some of which prevent foaming and accumulation of scale.

No. 10. (Water treated in reservoir by adding caustic soda sufficient to neutralize acid.) Apparently does not create any trouble.

No. 19. (Soda ash in locomotive tenders.) Is beneficial in retarding formation of scale and prolonging life of flues. Does more harm than good unless followed up by frequent blowing off and washing out. Has tendency to cause foaming and priming.

No. 21. (From one to three ounces per one thousand gallons in locomotive tenders.) We believe soda ash prevents, in a measure, the formation of scale and flue trouble.

No. 22. (Treat some waters by lime and soda ash in station tanks.) Prevents corrosion and largely reduces scale formation but does not seem to decrease flue leakage where total soluble alkalies, which can not be eliminated by chemical treatment, are in excess. If the total amount of these alkalies exceed thirty grains per gallon (whether naturally contained or introduced by chemical reaction) we would not consider there is any gain in trying to treat water.

Troubles from foaming and priming in road service with losses included may largely exceed cost of boiler repairs. Treated waters we find increase tendency to priming in direct proportion to amount of alkali added to water in treatment.

No. 23. With the Wefugo process we have not succeeded in purifying the water to such an extent as to overcome the trouble produced by bad water. With the Talmadge device we can run boilers from twelve to fifteen times the mileage between washings that we can with the Wefugo treated water. This is naturally much easier on the boiler as it eliminates the extreme expansion and contraction which constantly takes place during each boiler washing.

No. 24. Caustic soda in tanks of engines causes fire box and flues to leak, and flues to pit in some cases.

No. 28. Less leaky tubes and less trouble with scale if blow-off cocks are used regularly.

Question No. 11. Do you have more trouble from burned and cracked side sheets, leaky stay bolts, crown bolts and flues in large high-pressure boilers than in small low-pressure boilers?

Four roads report no more trouble.

Twenty-two roads report having more trouble.

No. 3. More cracked side sheets in large fire boxes and high-pressure engines. No more trouble with crown bolts and flues.

No. 4. Yes, a little more.

No. 5. About two to one.

No. 7. Slightly more.

No. 9. Somewhat more trouble from burned and cracked side sheets, leaky stay bolts, crown bolts and flues.

No. 12. To a small extent.

No. 19. Considerably more flue trouble, but the design of boiler appears to affect other troubles more than anything else. With wide fire

boxes having wide water spaces and long stay bolts, the only trouble of any consequence is leaky flues.

No. 22. More trouble from leaky stay bolts, crown bolts and flues, but not more burned side sheets.

No. 23. A great deal more trouble with leaky flues and stay bolts. Out of ten large high-pressure boilers with fire boxes 72 by 108, put in service new November, 1902, six now have side sheets cracked to such an extent as to make new sheets necessary.

Question No. 12. Do you have less fire-box and flue troubles with wide-grate boilers than narrow?

Seven roads say yes.

Eight roads say no appreciable difference.

Four roads say less fire-box and more flue trouble.

No. 2. Depends entirely on distance between the grate and lower row of flues. The nearer the grate to lower row of flues the greater the trouble with leaky flues.

No. 3. Some more trouble with flues in the wide-grate boiler than in narrow, in my judgment due to depth of throat sheet and location of fire relative to flues.

Question No. 13. Is shallow wide-grate boiler over drivers as satisfactory as a deeper fire box over trailer?

Nine roads say shallow fire box over drivers is not as satisfactory as deeper fire box over trailer.

Two roads say yes.

No. 4. Shallow fire box gives more trouble from leaky flues than deep boxes.

No. 14. The difference in depth of seven inches between our two classes of engines indicates that shallow grate is as satisfactory.

No. 23. In wide fire boxes with bottom of mud ring fifteen inches below barrel of boiler, have had a great deal of trouble with leaky flues. In wide-fire-box engines of same kind, except mud ring is twenty-three inches below barrel, have had little or no trouble with leaky flues.

Latter engines have hardly been in service long enough to judge correctly.

No. 27. Yes, more so for anthracite fuel.

Question No. 14. Have you had trouble with large high-pressure boilers priming?

Eighteen roads say no.

Seven roads report a little more.

No. 6. Yes, on mountain grades, in bad water districts only.

No. 8. Very little.

No. 9. Very little.

No. 15. To some extent.

No. 22. Have had some trouble with priming of large high-pressure

boilers even on mountain grades, where water is excellent, total solids not exceeding three grains per gallon.

Question No. 15. What space above crown sheet and flues do you recommend?

Space above crown sheet recommended varies from sixteen to twenty-four inches, with an average of twenty-one and one-half inches.

No. 6. Not less than twenty-eight inches over back end of crown sheet for eighty-inch boilers, and twenty-six inches over top of flues at back end and twenty inches at front end. Prefer more space than the above.

No. 25. Above crown sheet twenty-two inches. Conditions may make it necessary to reduce this.

Question No. 16. To what extent are you using wide fire boxes in recent engines?

Three roads report not using wide fire boxes.

Ten roads report all recent engines having wide fire boxes.

Two roads report all except switch engines.

No. 2. Seventy-five per cent of our engines have wide fire boxes.

No. 6. All engines recently built have wide fire boxes and are changing some of the narrow boxes to wide ones when have to replace fire boxes.

No. 7. All soft-coal burners semi-wide fire boxes.

No. 10. All passenger-engine grates from seven to eight and one-half feet wide on recent engines. Freight engines using soft coal use grates five to six feet wide.

No. 13. All new engines since December, 1901.

No. 17. All large consolidation engines.

No. 22. All, for coal fuel.

No. 26. About ninety-five per cent of all road engines.

No. 27. Entirely; have added two hundred in four years.

Question No. 17. What width mud ring and what water space at crown sheet do you recommend?

Replies vary for mud ring at side from three to five and one-half inches with an average of four inches, and for space at crown sheet from four and one-half inches to nine inches with an average of six and three-fourths inches.

Question No. 18. Do you have less broken stay bolts in wide fire boxes than in narrow?

Seven roads report less.

Three roads report very much less.

Two roads report no noticeable difference.

No. 6. Not much difference.

No. 8. No; probably more.

No. 9. About fifty per cent less.

No. 10. Use high grade stay-bolt iron and have comparatively little trouble with broken stay bolts in any kind of fire box.

No. 11. Yes, very much less.

No. 19. Yes, very much less.

No. 23. So far have had more broken stay bolts in wide fire boxes than narrow, but not prepared to say absolutely that wide box is cause of bolts breaking.

Question No. 19. What is the most satisfactory thickness of tube, side and crown sheets?

Fifteen roads report in favor of ½-inch back tube sheet, nine in favor of ⅝-inch, and one 13-16-inch.

Four prefer 5-16-inch side sheets, nineteen ⅜-inch, two 7-16-inch.

Eighteen prefer ⅜-inch crown sheet, seven 7-16-inch.

No. 6. Are using ½-inch tube, ⅜-inch side, ⅜-inch crown sheets. Are experimenting with thick sheet on one side and thin on other.

No. 8. One-half-inch tube, ⅜-inch side and crown, one piece.

No. 10. One-half-inch tube, ⅜-inch side and crown, one piece.

No. 26. Flue ½ and ⅝-inch, crown ⅜-inch, side ⅜-inch and over.

Question No. 20. Have you had trouble from leaky mud-ring corners, and have you found a remedy?

Fourteen report little or no trouble, and the cause is poor workmanship or design.

Four roads report having had considerable trouble when mud rings are machined to take full thickness of plates without scarfing.

Five report considerable trouble, but can be largely controlled by good workmanship and design.

No. 3. Have trouble, due principally to poor workmanship and methods of carrying boilers.

No. 5. Yes. No remedy other than caulking and renewing rivets.

No. 6. Have had trouble, and as a remedy are trying scarfing sheets that lap around corners.

No. 8. Yes, but found remedy in scarfed corners. Originally used butt corners.

No. 9. Very little trouble if sheets properly scarfed and lapped.

No. 10. Have had considerable trouble due to mud rings being machined to take plates without scarfing. In recent construction have scarfed plates at corners. Have also increased radius at corners.

No. 15. Have trouble. Only remedy is constant attention.

No. 19. A great deal of trouble with butt-joint corners. The remedy is to scarf the sheets and increase the radius of inside corners.

No. 22. No trouble from leaking. Have had trouble from breaking and have remedied by reinforcing corners by welding on piece ¾-inch thick and extending six inches both ways from angle.

No. 25. Some trouble when radii too short; no trouble when radii

are correct. Correct radii should not be less than three inches for inside corners and four and one-half inches for outside corners.

Question No. 21. In what style of boiler are leaky mud rings most prevalent, and what do you consider to be the cause?

No. 4. If work well done, double-riveted and fire heat kept from ring it should not leak.

No. 5. Greater in radial stay boilers, caused by expansion and contraction in three directions.

No. 6. When sheets let into mud ring they can not be riveted tight.

No. 9. More on high-pressure than low. With proper design of lap and good workmanship, trouble is very small.

No. 10. Narrow fire-box boilers.

No. 11. No particular style. Poor workmanship.

No. 14. If mud rings too small or have too small radius at corners they will give trouble.

No. 15. In narrow fire boxes.

No. 16. In narrow fire boxes, extended wagon top.

No. 19. In long, narrow fire boxes. Most noticeable in boilers giving most side-sheet and stay-bolt trouble, and is due to excessive expansion and contraction of side sheets.

No. 21. All high-pressure boilers leaked at corners on account of not being able to fit and fasten plates perfectly at that point.

No. 22. About same trouble in all styles of large construction. The cause is unequal expansion of metals in contact.

No. 23. More trouble with broken and leaky mud rings in wide fire-box engines, but believe more on account of poor workmanship and material than design of engines.

No. 24. No particular style.

No. 25. Those having radii in corners less than three inches inside and four and one-half inches outside.

No. 26. More trouble with wide fire boxes, but trouble is mainly poor workmanship.

No. 27. Cause, small rings, single riveted.

Question No. 22. Do you prefer two doors or one in wide-fire-box boilers, and why?

Eighteen roads have or prefer a single-door opening.

Seven have or prefer double-door opening.

No. 2. Prefer one door, because we are enabled to replace grate frames without taking down the ash pan.

No. 5. One door, account cracking sheets between doors.

No. 6. Have a number of engines with two doors and have had trouble from bad circulation between doors.

With some construction the doors are at such an angle and so small it

is difficult for firemen to throw coal to the end of fire box. Are now applying but one door to wide fire boxes.

No. 7. Single opening, double door, opening right and left. Better distribution in firing and advantage in cleaning fire.

No. 9. Have quite a number of fire boxes with two doors and have had trouble from cracking of back fire-box sheets. Shall probably substitute single doors as the sheets need renewal.

No. 10. One door, on account of flanging holes in back head.

No. 11. One door better for firing.

No. 13. Prefer one door for fire box up to seventy-two inches wide. Two doors for wider fire boxes.

No. 14. Two doors. Impossible to get good results with one door.

No. 15. Prefer two doors, as it gives fireman better opportunity to handle fire economically and efficiently.

No. 17. Prefer one door with room enough to handle shovel properly. With second door men have to fire left-handed, and they do not do it.

No. 19. One, because more convenient for fireman and cheaper to maintain.

No. 21. Prefer two doors in wide fire boxes of high-speed passenger engines in order to give firemen a better chance to fire the corners. One door in wide-fire-box freight engines.

No. 23. The double door seems to give better satisfaction. Our experience, however, has been limited with the double door as first wide-fire-box engines received had single doors. Now getting nothing but double-door boxes.

No. 24. One door sufficient, as firemen can place coal without having to work right and left handed.

No. 25. Prefer two. Fireman can distribute coal better.

No. 26. Have used two doors extensively, but are somewhat convinced that a single door of good proportion is more advisable, inasmuch as the fire can be handled as well as with two doors and there is a consequent reduction of parts and less opportunity for trouble with fire-door opening.

No. 27. Two. More comfortable and better results firing one side at a time.

No. 28. Two doors, because it is easier for the fireman to keep fire in shape, as he can reach the sides and corners of fire box better.

Question No. 23. What form of fire-door flanging and fitting have you found to give best results?

Nine roads prefer flanging back head in, back sheet out and riveted between.

Eleven roads prefer flanging both sheets out, some using joining rings.

Only three drawings received show circular door openings.

Of the roads reporting the most boiler trouble, nine prefer flanging both sheets out, and five prefer flanging sheets toward each other.

No. 2. Greatest trouble with wide fire boxes has been around furnace doors, and not in a position to make a recommendation.

No. 6. Best form for wide fire boxes is to flange out inner and outer sheets and riveted together on outside. With very wide water space both flanged out and internal joint ring is satisfactory.

Question No. 24. What construction of ash pan have you found most successful for wide-fire-box engines? Please send drawing.

Owing to shortness of time in which to prepare this report, no illustrations are shown. It is hoped before report is printed in Proceedings to show drawings.

Question No. 25. Have you used flexible stay bolts, and have you found them an economy?

Eleven roads have not used flexible stay bolts.

Seven have used them with satisfactory results.

Six are experimenting with them, but have no data yet.

Four have used them, but found no advantage in them and have given them up.

No. 6. After having experimented considerably, have discontinued them.

No. 8. Yes, no economy.

No. 9. Have used several forms of expansion stay bolts, but discarded them.

No. 10. Have only one engine equipped with flexible stay bolts, turned out in August, 1900, and has run since then without breaking any stay bolts. This bolt is of our own design and is covered by patent.

No. 12. Only at corners of fire box. Good results.

No. 16. Yes, see discussion, 1902 Proceedings.

No. 21. Two large high-pressure consolidation engines fitted with flexible bolts six months ago, but not in service long enough to determine whether or not economical.

No. 23. Apply flexible stay bolts as follows: All bolts in throat sheet, three outside rows, and three top rows in back head, and four outside rows and four top rows in side sheets.

No. 27. Yes, to some extent. None have failed to date.

Question No. 26. Please send drawing of your most satisfactory grate for soft coal, and say if you use drop grate in both narrow and wide fire boxes.

Four do not use drop grates in wide fire boxes.

Of those who do use drop grates, some put them in back end of fire box, others in front.

No. 26. We use long fingers for clinkering coal, short for free burning coal.

Question No. 27. If you have troubles from leaky flues, to what extent are they due to poor coal, poor water, length of flues, spacing of flues, steam pressure, width of fire box, severity of service, or other causes, and why?

No. 1. The only leaky flues we have are account of severe service, especially hill service.

No. 2. Can be attributed to two causes: One, account grate too near lower flues on soft-coal burning engines, and the other, poor fuel.

No. 3. Have some trouble and believe it due to poor workmanship in the manner of setting and caring for the flues, in washing and blowing out boilers, treatment of water, firing engine, and quality of coal. The last can largely be reduced by having one kind of coal furnished regularly, so men become familiar with same.

No. 4. Very little trouble, and am of opinion poor coal and water have very much to do with it.

No. 5. Trouble caused as follows: First, poor water; second, bad coal; third, severity of service; fourth, length of flues; fifth, steam pressure. Two important items are cooling at ash pit so suddenly, blowing off pressure in roundhouses for boilermakers to work.

No. 6. Some trouble due to bad water, but principal cause is severity of service. One cause is improper care of boilers at roundhouse, and possibly introduction of feed-water when engine is standing on side track.

No. 7. No particular trouble.

No. 9. Having some trouble, and it is probably chargeable to bad water, high steam pressure, severe service, improper firing, and defective circulation.

No. 10. Due to poor coal, inexperienced firemen and severity of service.

No. 11. One hundred per cent; nothing else to cause them.

No. 12. Main trouble is poor coal.

No. 13. Mostly due to bad water, and to a number of engines built several years ago with flue sheets ¾-inch thick.

No. 14. Poor coal causes some trouble on account of difficulty in cleaning fires and excessive use of blower. Hard water makes frequent caulking necessary.

Do not consider the length of flues makes any difference.

No trouble account of high pressure.

No trouble on account of width of fire box that could not be traced to negligence on part of man on engine.

Severity has its influence account of greater amount of coal consumed and consequent increase in amount of wear.

No. 15. Due mostly to severity of service.

No. 16. First, poor water; second, severity of service; third, high steam pressure; fourth, poor coal; fifth, length of flues; sixth, spacing

of flues; seventh, width of fire box. Other causes, improper draft and weather conditions.

No. 17. Mostly due to bad firing.

No. 19. Leaky flues are principally caused by overheating of the back flue sheet and flues. The overheating is due to poor circulation, which is the result of bad water, severity of service and contracted water spaces, high steam pressure, scant steam space. Wide and sudden ranges of temperature produced by poor coal, poor firing, width of fire box and abuse by blower, add to the effect of overheating.

No. 21. Ninety per cent due to bad water and coal.

No. 22. Have in some districts much trouble with leaky flues, generally attributed to use of poor water in which soluble alkalies (salts of soda) are in excess.

Have no evidence that poor coal is responsible for the trouble.

No additional trouble with flues up to sixteen feet long.

Severity of service has much to do with it. Rapid or sudden changes of temperature at flue sheets are more liable to occur with severe service and leaky flues follow in direct proportion.

Have more trouble with flues in oil burners than with coal fuel, as there is liability to greater range or sudden changes in temperature in fire box with oil fuel. Unequal and irregular expansion of fire-box sheets with severe service are responsible for most leaky troubles. They appear to increase in direct proportion to the severity of service and steam pressure or increased temperature which produces these irregularities.

Bad water finds weak places and exit sooner than good water.

No. 23. The principal causes of trouble are very bad water, severity of service, often bad fuel, and enginemen not taking care of wide fire boxes.

One reason for this is impossibility of assigning regular men to each engine. The larger the engine the greater the expansion and contraction, therefore the greater damage on account of neglect by enginemen permitting engine to suddenly cool or increase rapidly in steam pressure.

Length of flues must have some influence, although we have some engines with two-inch flues, No. 11 gauge, fourteen feet eight inches long, in wide-fire-box engines that give a great deal of trouble. On the other hand, have two engines with two and one-quarter inch flues, No. 11 gauge, twenty feet long, which have so far given scarcely any trouble, but have not run long enough to say what final outcome will be.

Spacing has a great deal to do with leaking.

If bridges are small they will not stand rolling without stretching, and, in such cases, it is almost impossible to roll flues tight. The bridges should not be less than three-quarters of an inch, and am satisfied better results can be obtained from seven-eighths or even one inch, even though heating surface be reduced on this account.

No. 24. Do not think poor coal is responsible for leaky flues. Poor water causes about seventy-five per cent of trouble. No trouble account length of flues. Spacing causes about five per cent, steam pressure five

per cent, width of fire box no difference, severity of service fifteen per cent.

No. 25. No flue trouble; longest tube sixteen feet.

No. 26. Due to poor coal, but mostly to severity of the length of service.

No. 27. Poor coal and severity of service.

No. 28. There is no doubt that leaky tubes are sometimes caused by poor coal, necessitating abnormal practice in handling both fire and water supply. Bad alkali waters also cause trouble by forming hard scale around the necks of the tubes, thereby keeping the water from contact with the tube and tube sheet, allowing an undue amount of heating and expansion. I do not think the length of tubes has much to do with the matter, but the spacing will certainly have; if the tubes are very close together the scale which forms on them closes the water space more quickly and so affects circulation, and often around the neck of the tubes near the tube sheet completely joins, covering the bridges entirely, and then nothing will keep them from leaking and eventually cracking the bridges and burning the heads off. The higher the steam pressure, the greater leak, with the same opening. Width of fire box does not affect the tubes as much as shallowness between tubes and grates. Severity of service, of course, affects the tubes in the same way it affects the rest of the engine.

Question No. 28. What is the length, size, gauge, spacing and number of tubes in boilers which give most trouble from leaky tubes?

Length varies from eleven feet six inches to eighteen feet four inches, with an average of fifteen feet; size two inches and two and one-quarter inches; gauge 12 to 10; spacing 57-100 to ¾; number of flues, 200 to 365.

No. 2. Most successful engines have tubes fourteen feet eleven inches long. Have some trouble with older design boilers with shorter tubes, and more spacing, so it can not be attributed to length of tubes. Use No. 10 ends and No. 12 flues.

No. 3. Use No. 11 gauge with Swedish iron safe ends and body grade tube. Have not discovered any difference so far as number of flues is concerned.

No. 6. Have similar trouble with long or short flues, of different diameters, and with different spacing.

No. 11. Can not trace any connection.

No. 21. Have not been able to overcome this trouble by spacing, gauge or number of tubes.

No. 28. No class of engine is particularly troublesome in this respect, but tubes No. 12, B. W. G. thick, spaced closely together, give trouble.

Question No. 29. Do you have more trouble with leaky tubes in wide fire boxes than narrow?

Ten roads report no more trouble from leaky flues in wide fire boxes than narrow.

Seven roads report more.

Four report no noticeable difference.

Question No. 30. Have you increased spacing of tubes in recent boilers, and, if so, has it been of any benefit?

Seventeen roads report they have not increased the spacing of flues.

Seven roads report they have increased spacing.

No. 2. In boilers that gave trouble four or five years ago, having 2-inch tubes 13 feet 6 inches long, we began, when applying new flue sheets, to use 1¾-inch safe ends on 2-inch tubes. Did not interfere with steaming and materially increased life of flues.

No. 4. Yes, ⅝ to ¾-inch.

No. 6. Spacing several years ago for 2-inch flues was 2⅝ inches. Now spacing 2 11-16 and 2¾ inches for 2-inch; 2⅞ inches for 2¼-inch, and consider the increase to have been beneficial.

No. 7. No; standard spacing, 2¾ inches.

No. 11. Have increased spacing for 2-inch flues to 3 inches and it does not seem to be of any benefit.

No. 19. Are now spacing 2-inch flues 3-inch centers, and have found it beneficial, but not a cure.

No. 21. Yes, but have not overcome leaking.

No. 24. Yes. Benefits derived are longer lived flues and flue sheets.

No. 25. We shall increase spacing in some new boilers.

No. 27. No; would be very beneficial with very bad water.

No. 28. Yes, and wider spacing gives better results.

Question No. 31. Do you use brick arches in shallow fire boxes, both wide and narrow?

Thirteen roads report using brick arches in all engines.

Eight roads report using no brick arches.

Three roads report using brick arches in narrow fire boxes only.

No. 17. Yes, all using soft coal.

No. 21. No, because have not been able to maintain them on account of quality of water and large amount of flue work.

No. 24. Yes, all boilers in good water districts. Can not use them in bad water districts because of tendency to burn and blister the supporting-arch flues.

Question No. 32. How are arches supported in each case?

Three roads report they support arches on studs or angle irons bolted to side sheets of fire box.

Eight roads report using arch tubes only.

Seven roads report that they use angle irons or studs in narrow and arch tubes in wide fire boxes.

No. 1. On studs. Prefer flues but afraid of them bursting.

No. 6. Angle irons on side sheets, narrow fire boxes, and on angle irons, also on circulating tubes wide fire boxes. Prefer angle supports to circulating tubes on account of circulating tubes splitting at or close to bend at lower end.

No. 8. All brick arches on angle irons studded to side sheets.

No. 9. In fire boxes, forty-two inches wide or less, support arches on angles. In wide fire boxes, on tubes.

No. 11. Three-inch arch tubes.

No. 14. Water tubes No. 7, three inches diameter.

No. 15. In deep boxes, on lugs screwed in side sheets. In shallow, on arch tubes.

No. 17. Some on studs, some on tubes. With good water, water tubes best.

No. 19. In narrow boxes, on studs. In wide boxes, on studs screwed into side sheets and one four-inch No. 7 arch tube in center.

No. 22. In narrow boxes on 1¼-inch square bars, resting on heavy studs in side sheets. In wide boxes on arch tubes.

Question No. 33. If you have used any form of smoke consumer, what has been its effect on fire box, flues and coal consumption?

Fourteen roads report they have not used any form of smoke consumer.

No. 1. Have one Franklin in service since October, 1902. Seems to work satisfactorily, and engine is considerably lighter on coal than others of same class. This economy due to the double arch. Do not approve of flues admitting cold air over top of arch. It seems that the extreme heat will be severe on crown sheet. Will keep flues from leaking that otherwise would leak.

No. 2. Use Bates fire door in narrow boxes, which almost entirely eliminates black smoke, and is showing nice saving in fuel. Have hard road to operate, and firemen have no trouble maintaining pressure with the scoop known as the " furnace scoop," which is the smallest scoop made.

No. 3. Use combustion tubes in fire boxes of all boilers with steam jet entering the same as smoke consumers. Have discovered no bad effects on fire box or flues, but believe it consumes more coal.

No. 14. Use Coffin-McGeath consumer. Can not say that any injury is done to flues, but it does make necessary caulking more difficult.

No. 15. Use Coffin-McGeath consumer. Not in use sufficient length of time to determine its effect on fire boxes and flues. We get a saving of about twenty per cent in coal.

No. 16. Use a combination steam and air jet consumer, and have noticed no changes in fire box or flues or an appreciable reduction or increase in coal consumption.

No. 19. Have used Coffin-McGeath consumer on one engine for a short time. When opening between arches is correct does not seem to injure fire box and flues. Consumes most of the smoke and effects about ten per cent saving in coal.

No. 22. Only smoke consumer we have used is Bates' fire door, with inside baffle plate to direct air downward. Seems generally effective in smoke combustion, but have found no material effect on coal consumption.

If current of air is deflected over arch and strikes flue sheet, we have leaky flues.

No. 27. No, do not need with hard coal.

The committee has reached the conclusion that boiler troubles have increased in proportion to the increase in size and steam pressure of boilers.

Those roads having very little trouble with old boilers are having very little more with modern boilers, and those which have always had a good deal by comparison, are having a good deal more with their modern boilers. Poor water is evidently the chief cause of boiler troubles, though it is evident that poor coal, severity of service, contracted water spaces, etc., contribute to an aggravation of the trouble. It would appear also that in poor water the incrusting solids are not always the governing factor, but that other solids also have their effect in producing cracked side sheets and leaky flues.

One horse-power for three square feet of heating surface seems to be about all that can be safely relied upon as a regular performance with water ordinarily found in the Middle and Western States, but this can be improved upon where water is of better quality.

There seems to be no question but that the wide grate is at least ten per cent more economical than the narrow, in burning bituminous coal, but that its economy while running is to some extent offset by its comparative waste of coal while standing idle on side tracks or at terminals, and this waste appears to increase proportionally to the increase in grate area.

No conclusion could be made as to the maximum grate area which a fireman can economically fire, but it no doubt depends on the quality of the coal, and for a clinkering coal would appear to be in the neighborhood of forty-five square feet.

Treating water in locomotive tenders is undoubtedly beneficial, provided it is followed up with frequent blowing down and washing out, in that it retards the formation of scale and overheating. The quality of the water may be so poor, however, as to require so much soda ash or other reagent and hence so much washing out that the good effects of the soda ash are offset by the bad effects of too much washing out.

The correct method of treating water appears to be in station tanks, so that solid matter does not get into the boiler, but even by this treatment there seems to be danger of making the water so alkaline as to foam badly, as noted in reply No. 22 to question No. 10.

The committee would call attention to reply No. 23 in this connection.

From replies to questions No. 12 and No. 29, the committee would judge that there is materially less trouble from broken stay bolts and cracked side sheets with the wide fire box than the narrow, but about the same amount of flue trouble, although several roads state that they have decidedly more leaky flues in wide fire boxes. The general opinion is that the deeper fire box over trailers is more satisfactory than the shallow box over drivers.

In general there is no increase in foaming or priming in high-pressure boilers, but the committee would recommend as much steam space as is possible to get and a comparatively high dome.

The committee would also recommend that unless water is exceptionally good, the width of mud ring be not less than four inches and the space at crown sheet not less than seven inches, believing that it will result in much longer-lived side sheets and considerable reduction in broken stay bolts.

A large majority of the replies express a preference for ⅜-inch side, door and crown sheets, and ½-inch flue sheets.

Attention is called to replies No. 6 and No. 26 to question No. 19, relative to thicker side sheets.

Double riveting mud rings, scarfing sheets at corners and an inside radius at ring of two to three inches appears to overcome all trouble from leaky mud rings.

A considerable majority of replies consider one door sufficient for wide fire boxes, and where there is trouble from door sheets cracking, the most satisfactory method of flanging appears to be to flange both sheets out, the inside sheet to have large radius.

A considerable majority of roads appear to use drop grates and the need of them no doubt increases with the tendency of the coal to clinker.

Flexible stay bolts are still in the experimental stage and the committee would refer to the topical discussion on this subject in 1902 Proceedings, page 378.

The economy of the brick arch seems to be unquestioned, especially in deep fire boxes, but in shallow boxes and those subject to leaky flues, it is not so much favored. Water tubes are the favorite means of supporting brick arches where the water does not cause them to give trouble. Where water is poor the supporting of arches on angle irons or studs in side sheets is preferable.

In general, the committee is of the opinion that the large, high-pressure, wide-grate boiler can be designed to give very little more trouble than the old-style low-pressure boilers, even where poor water is used, except as regards flue trouble, which appears to be quite general and with most roads quite serious. Wide water spaces around fire box will prevent cracked side sheets and broken stay bolts to a large extent; good design will stop door-sheet and mud-ring trouble; wide bridges will prolong the life of flue sheets. A large number of flues, closely spaced, severity of service, poor water, contracted steam space, shallow depth below flues have retarded circulation to such an extent that flues and back-flue sheet are frequently and highly overheated. Wide fire boxes, poor coal and poor firing admit large volumes of cold air against overheated flues and sheets and the wide range of temperature to which flues are subjected loosens them circumferentially and draws them in and out longitudinally. Flues are frequently found so loose that they can be shaken in the sheet. Short pieces of flue rolled into a piece of ½-inch fire-box steel in the usual

manner, heated to a dull red and suddenly cooled require a considerable number of heatings to make them loose.

This is not exactly a parallel case to flues in a boiler, but the conditions are somewhat similar.

An experiment was made to determine the temperature surrounding flues by plugging certain flues at both ends with asbestos and placing asbestos plugs two feet apart throughout the length of the flue with two pieces of fusible metal in each space, one piece melting at 410° to 420° and the other from 440° to 450° Fahr. The results are given in Table No. 3, and show that the temperature surrounding flues was considerably above the temperature of saturated steam at 220 pounds at the back end and in the case of upper flues it was higher all the way through.

If the surrounding temperature is so high in a flue thus plugged it must be still higher about flues through which fire is passing, and it is probable that the temperature at flue sheet is very much higher. There is no evidence to prove that a flue will not stand a considerable amount of overheating without leaking, but it would appear that those that are leaking are subjected to too high and too great a range of temperature.

It is only necessary to have a sufficient body of water against side sheets to reduce cracked side sheets and broken stay bolts to a minimum. It should follow that flues can be spread far enough apart to stop their leaking, but the spreading of flues reduces the heating surface very rapidly and the widest spacing the committee has knowledge of, namely, 3½-inch centers for 2-inch flues, has not cured the trouble.

In conclusion the committee would recommend the appointment of a committee for the ensuing year to further investigate the question of leaky flues.

D. Van Alstyne, Chairman,
G. R. Henderson,
T. W. Demarest,
O. H. Reynolds,
John Player,
Committee.

St. Paul, Minn., May 5, 1903.

Mr. Van Alstyne: The committee feels like making an apology for the incompleteness of the report, but it was due to a misunderstanding that the work was not begun until about two months before the convention. The report is divided into two parts.

Part one describes and illustrates representative foreign and American boilers for various kinds of fuel. In this connection I would call your attention to the remarks on page 4, relative to the wider flue space and better circulation.

The recent joint designed by the Baldwin Locomotive Works has been called to my attention since the report was handed in, which has an efficiency of 97.4 per cent, and a description of which the committee hopes to incorporate in the report before it is printed in the Proceedings.

Part two is based on about thirty replies to a circular relative to the service and efficiency of the modern high-pressure boilers and is fairly representative of the practice and experience throughout the country. After the report was handed in, a half-dozen replies were received, but they were too late to make any use of. A large number of blue-prints were also received, but the illustrations in certain of them had to be left out of the advance report for want of tracings. To express the conclusions of the second part in a few words, the modern high-pressure boiler, especially with the wide grate, is doing all, or can be made to do all, that is expected of it in every respect, except as regards flues. Wide water spaces around the fire box, especially at the crown sheet, long stay bolts, easy curves at doors and mud rings and scarfed mud-ring corners, in general, have to a great extent done away with cracked sheets and broken stay bolts and troubles from fire box leaking.

There appears to be no question but that the wide grate engine is ten per cent more economical of fuel than the ordinary narrow grate of 40 and 42 inches, with the same heating surface. But, on the other hand, the wide grate is certainly more wasteful of coal when standing on side tracks and at terminals, and, apparently, the increase in coal consumption is about proportional to the increase in grate area.

There is no complaint against the free steaming of modern high-pressure engines as a rule, and very little complaint of foaming or priming. Flue troubles, however, are very general and vary from conditions where there are few failures, but a steady tinkering at flues in roundhouses, to conditions where failures are numerous and flues are renewed in three or four months. The causes generally ascribed as being responsible for leaky flues no doubt have their effect, but so far as I have gone in this investigation, it is my belief that they are not fundamental causes. It is not altogether a question of bad water, because there are instances of change from good to bad coal causing a great

deal of flue trouble and a cessation of the trouble when the change was made back to good coal again. Besides, there are instances of flues leaking a few trips after the engine leaves the shop, where there could not have been any scale on the tubes which would be responsible for any great amount of trouble. It is not due to the length of the tubes, because there is plenty of evidence that there is as much trouble from short tubes as long ones, and the same applies to the size and to the gauge. Mr. Ball's remarks yesterday bore on that question. It is not a question of the method of setting; that was clearly brought out yesterday by the opinions expressed, in which some members had entirely done away with the flue roller, some had abandoned the expander and others had some special form of beading tool. It is not due to lack of care, which I think was clearly brought out by Mr. Humphrey's remarks when he cited the case of engines running into the same terminal from two different directions, the engines from one division giving no trouble and the others giving a great deal of trouble. It is not a question of spacing the flues, although there seems to be quite a general opinion that wider spacing has done some good. So far as the committee's knowledge goes the wider flue spacing does not cure the trouble, and from the Lake Shore's reply they do not consider it has been of any benefit. I believe it is a benefit in this way: That the wider apart the flues are, the greater percentage of time they will be surrounded by water and hence less highly overheated.

No doubt all these foregoing causes have their effect, but so far as I have gone into the investigation, I do not believe they are the fundamental cause of the trouble, and in this connection I want to call your attention to the experiment that is described on the last page of the report and the figures given in the last table. In that experiment three tubes on each side of the vertical center line in the boiler, carrying 220 pounds pressure, having 18-foot 2¼-inch tubes, No. 11 gauge, were plugged up tight with asbestos plugs at both ends and asbestos partitions throughout the full length of the tube, about two feet apart, and in each compartment there were two pieces of fusible metal, kindly furnished by Dr. Thurnauer, of Aurora, and he vouches for the accuracy of the melting point within the limits given. One of the metals melted between 410 and 420 and the other between 440 and 450.

You will notice the higher tubes, 6 and 4 on both sides, melted the lower metal all the way through and the higher about half way through, and the two sets were exactly alike. A little lower down, the higher metal did not melt so far toward the front end and at the bottom the higher metal did not melt at the back sheet, and neither one melted in the seven front compartments. Of course, we do not know how much higher than 450 degrees the temperature may have been, but the saturated steam at 220 pounds pressure is about 380 degrees, and a good deal of overheating is indicated. These fusible metals, being melted in tubes closed and through which no fire was passing, makes it evident that the temperature inside of the tube, that the fire is passing through, is very much higher than that, and I am of the opinion that the temperature at the flue sheet, the joint itself, is very high, perhaps a thousand degrees. On the other hand, there is no reason for supposing that the joint between flue and sheet will not stand a very high temperature without leaking. An experiment I made to show that, consisted in rolling some short sections of tubes into a piece of half-inch boiler plate, in various ways; with copper ferrules, without bead, and without ferrules, of various gauges, and heating them repeatedly and cooling them in water, and it took a long time to make any of them loose. It is not exactly a parallel case with the boiler, because in the latter case the tube is fixed at both ends and has a constant pulling from the front sheet. You will note in this test the lower tubes that were tested were the cooler, because they melted less metal. It is a fact with that particular boiler, and all the boilers I have had any experience with, that it is the tubes below the center line that give the trouble and they are the ones least overheated. Just what the explanation of that is I do not know, except that it occurs to me that the feed-water settling at the bottom keeps the back tube-sheet cooler at the bottom than at the top, and the tube does not transmit the heat as it should into the sheet; it tries to expand and is compressed. I have very often found tubes at the bottom that I could put a hammer handle into and shake in the hole.

I believe that the fundamental cause of the trouble is circumferential contraction and expansion of the tubes at the sheet, and that the remedy for it is not necessarily to keep the sheet cool, but it is necessary to make the flue and the sheet expand and contract

together. In the top flues it is quite probable that there is a very much higher temperature of the flue sheet, because of so much steam (and I doubt if there is much water against the flue sheet at the top at any time), so the sheet expands with the tube and we have less leaking. I am inclined to think the advantage of the depth of fire box, which is generally recognized to be an advantage, and was noticeably so recognized in the replies to the circular, is due more to the fact that it provides a reservoir for cold water, and keeps the colder water away from the bottom flues, than it is to the fact it provides greater depth from the flues to the grate. Of course, that is only surmise.

Whatever the cause of leaky flues may be, the work on this report has impressed me very thoroughly that it is about the most important thing that the railroads have to deal with now, and that leaky flues probably have a greater influence on locomotive performance than any other one feature.

I very much hope that this investigation of leaky flues will be continued next year. I believe there is a good deal more information to be obtained, and perhaps some remedy will be discovered. It was unfortunate that these temperature tests could not be made more extensive. We were working a good deal in the dark, and about the time we got started the metal gave out, the time was short and we had to give up further tests.

MR. E. W. PRATT: It seems to me, from the western standpoint, that this is the most interesting paper at this convention. I can reiterate what the chairman of this committee has just said, in regard to the economical performance of the locomotive being based, especially in the West, not alone on the efficiency of the boiler, but the protection of the boiler from failures by leakage. With reference to the remarks concerning expanding and rolling flues, it seems to me that those who advocate the use of expander, which forms a joint on the inside and outside of the flue sheet, have something in their favor from a practical standpoint. It has been found by a good many that where flues continually leak, by driving solid plugs into four or five flues located in the leaky section, within a circle a little below the center line, by plugging four or five of the flues solid in the back flue sheet and compelling expansion to take place in the front end, the trouble from leaky

flues was reduced more than one-half, and was not increased proportionately in the front end.

I can not agree with the remarks of Mr. Van Alstyne in regard to long and short flues. As far as our troubles go, we have had more difficulty with the long flues than with the short flues. Some of that may be caused from the higher boiler pressure, but from the above-mentioned practice of plugging certain flues where the expansion is too great in the back flue sheet, it seems to me that the long flues, having the greater expansion account for this greater leakage, as well as the higher boiler pressure. We had a locomotive in a very bad water district which had the fire box renewed oftener than once in twelve months, for two successive periods. The experiment was made of running a 4-inch pipe from the belly of the boiler, just below the boiler checks, splitting this 4-inch pipe just forward of the fire box, and allowing a 2½-inch pipe to enter the middle of the side sheets at each side on a level with the grates. This fire box has been in use over two years with that circulating pipe, and we feel in that particular case we have made great improvement, and are to continue similar experiments on some other locomotives. The excessive heating of the side sheets seem to indicate that the cooler the water that enters the legs of the fire box the less expansion and contraction there will be in the side sheets, although our old practice of admitting the feed-water to the forward portion of the boiler, in order to keep it away from the heated sheets, pointed to the contrary.

Mr. John Player: The subject of leakage of flues, in wide-fire-box boilers especially, is quite an interesting question. The last speaker mentioned the fact of plugging up several of the flues in the back flue sheet. As I understand it, this was in a wide-fire-box boiler. Mr. Van Alstyne has spoken of the temperature in the flues of the boiler upon which he made his experiments, the distance apart of the flues being, I understand, ⅞ of an inch. It is unfortunate that the experiments Mr. Van Alstyne conducted could not have included a test upon a boiler having the flues of larger pitch, to determine the relative temperature in the flues between small pitch and large pitch. The fact of plugging the flues in the back flue sheet, mentioned by the last speaker, tending

to decrease the leakage, to my mind is not on account of a reduction in the expansion and contraction of the flue in sheet, but on account of decreasing the temperature surrounding the remaining flues by decreasing the amount of heat going through, and in other ways allowing a better circulation of water around the remaining flues to keep them cooler. Trouble with leaky flues has been experienced in wide fire boxes to a large extent. This is partly due, in original installations of wide-fire-box engines on new roads, to inexperience on the part of hostlers and firemen in handling the engines, causing them to leak in the first place, but the subsequent leakage, which has been greater than in narrow-fire-box engines, is caused by the more intense heat against the flue sheet. In wide-fire-box engines the grate area is increased something like fifty per cent over the narrow-fire-box engines. The fire-box heating surface is reduced; the length of the fire box being materially reduced. In the wide-fire-box engine a great portion of the heat generated by the combustion at the rear portion of the fire box becomes absorbed by the side and crown sheets of the longer fire box. In the narrow fire box this is not so — the greatest heat is against the flue sheet. The temperature at that point is of greater intensity than is obtained under the conditions of the narrow-fire-box engine. This is what causes leakage — the mechanical action of the beading or rolling of the flues in the sheet to a certain extent hardens them after the flue is put in. The intense heat projected against the ends of the tubes softens them and loosens them in the sheet. Mr. Van Alstyne speaks of the flues in the lower portion giving more trouble than those in the upper portion. This is due to the fact that more intense heat in the wide fire box is projected against the lower flues than the upper ones. Furthermore, the temperature of the upper portion of the flue sheet and rear end of the flues is more uniform than in the lower portion, because there is an absence of water, or at best there is a very small portion of water against these flues at that point. I think the subject of circulation in these high-power boilers is of importance and should be taken up in connection with the design of the boiler itself. The present practice of applying injector checks at the forward end, and having the water discharge against the flues interferes with the natural circulation of the boiler to a great extent, in that the cir-

culation is upward and forward at the back, and, as we understand, downward at the front and rearward at the bottom toward the fire box, the tendency of the flow of water being to accelerate in the neighborhood of the flue sheet. The absorption and evaporation of this amount of water at that point, and the very excessive upward circulation of the water going back along the legs of the fire box toward the back head, and that is one of the causes of the trouble with the side-sheets. The water becomes intensely hot, and the water circulated downward is very hot when it gets there. We need colder water against the flue sheet, and at the point in the boiler where the greatest amount of heat is generated and transmitted to the water, I think if the circulation and the application of the feed-water was improved in the direction of circulation, we would obtain better results. To this end I would suggest that experiments be made in applying feed-water at the bottom at the forward end, directing the circulation backward, and if necessary take out some flues to provide sufficient passage. Another important feature in wide-fire-box boilers is to enlarge the water space at the flue sheet, so as to provide sufficient circulation to take care of the water legs at the side. In many recent boilers we have built we have made the space at the upper portion of the leg at the flue sheet seven inches, and four inches at the bottom, being a gradual taper. It has improved the durability of the side sheets and also flues in otherwise similar boilers.

In regard to the matter of spacing the flues, I think if we could obtain a wider horizontal spacing at the back end, the vertical space might be left as it is. What we require is ample room between the flues to obtain a rapid circulation vertically. Horizontally, it does not make much difference.

In connection with high-efficiency joints in the barrel sheets of the boiler I am constrained to believe that we should not exceed a joint having an efficiency of eighty-five to ninety per cent, which is obtained by the ordinary sextuple-riveted joint, due to the fact that we have to pay some attention to the circumferential seams in large boilers and have a sufficient thickness of plate and seams to withstand strains imposed thereon by the vibration of the engine transmitted through the frames and bracing of the boilers. I think it would be unwise to reduce the

thickness of the barrel sheets to a minimum, because trouble would be then experienced at other points.

MR. ANGUS SINCLAIR: I move that the further discussion of this subject be postponed until to-morrow morning.

Motion seconded and carried.

The meeting then adjourned.

FRIDAY'S SESSION.

President West called the meeting to order at 9:45 o'clock.

THE PRESIDENT: The business to be considered is the continuation of the discussion of the report on "Recent Improvements in Boiler Designs," which was under consideration when we adjourned yesterday.

MR. D. VAN ALSTYNE: I do not know that I laid sufficient stress on the points I tried to bring out yesterday, or the one particular point in regard to leaky flues, and that is, while the length of tube and tube space, bad water, coal, poor firing and irregular feeding, certainly contribute to aggravate leaky flues, I do not consider any of them the fundamental cause. What I believe to be the principal cause of flue trouble is the difference in the temperature between the flue and the flue sheet at the joint. The fire passing through the flue very highly heats it and the heat is not, I think, transmitted through the ferrule into the sheet as rapidly as it goes into the flue at the joint, and at the bottom the sheet is kept more or less cool by the water which is against it, but it is allowed to become very hot at the top where there is probably nothing but steam against it. Therefore, at the bottom the flue holes do not increase so much, whereas the tube tends to expand considerably and is compressed. At the top the sheet and flue expand more nearly together, and the joint remains tight. I think it is for that reason flues leak more below the center line than above, and I think also that this is the explanation of the fact that engines are constantly coming in comparatively tight, and, after standing on the cinder pit, they begin to leak. The reason is the steam pressure gets low, the fire gets low, the engine cools off and the lower tubes contract to a smaller size and naturally begin to leak, and the hostler gets the blame.

It is not merely a question of circulation, although good circulation is of great importance, and can be obtained by increased spaces around the fire box and between the flues. I doubt if any change in location of checks will materially affect circulation. While steam is generated circulation necessarily results, and sufficiently wide water spaces must be provided to enable steam to get out quickly and water to take its place.

If the above explanation of leaky flues is correct, the important thing is to keep cold feed-water away from back flue sheet as much as possible. The fact that the trouble is worse with bad water is, perhaps, due to the solid matter in the water getting between the sheet and flue, forming an insulation and allowing a higher degree of overheating of the flue as well as a coating which reduces the size of flue hole and produces a greater compression of the flue.

MR. DAVID BROWN: I have been much interested in the remarks of Mr. Van Alstyne as to the reasons for leaky flues. Many of the members frequently connect the wide fire box with leaky flues, as if the wide fire box is the main cause of the trouble. Our experience has been different from that. We have been using wide fire boxes for twenty-four years, commencing with a fire box 7 feet six inches, until they are now 9 feet, and we have over eighty-five per cent of the engines equipped with that fire box. We do not consider that we have any more trouble from leaky flues with the wide fire box than we had with the narrow fire box; in fact, the flues at the present time are giving us very little trouble, where we have good water. On the west end of our system we have more trouble than on the other terminal, as the water is not so good. We also have less trouble with side sheets on our wide fire boxes than with the narrow ones.

Previous to 1876 our gauge of track was 6 feet, and in that year the track was narrowed to 4 feet 8½ inches, and, of course, the fire boxes were also narrowed. We soon found that our side sheets were suffering more than formerly, especially on engines in hard service. In one case of a passenger engine, on a heavy, hard run, it had three new side sheets in five years. We attributed it to the intense heat of the narrow fire, causing the water to form bubbles, following up the sheet in a frothy condition, consequently

punishing the sheet; in other words, the water was not solid enough to protect the sheet from the intense heat which the narrow fire box had to furnish to provide the necessary steam to haul the train. Shortly after we began using the wide fire box that reached even with the outside and on top of the frame, we noticed an improvement, and when we still further widened the fire box to 7 feet 6 inches, and from that gradually to 9 feet, we have had very little trouble from our side sheets. The grate area being so large, the heat through the fire box is not so intense and the sheets are not punished, as formerly. We certainly have obtained great results from our wide fire boxes, and, as stated before, leaky flues is one of the least of our troubles where we have good water.

As regards our modern boiler, I consider we are improving the boiler by widening the fire box, knowing what we have done in that respect. The first consideration is steam, to produce which we must have ample heating surface, or, to go a little further, an abundance of it. To procure this steam we must have all the boiler capacity we possibly can, and, of course, all the heating surface obtainable. The next consideration is safety, and in that respect I consider our present factor ample, with the exception that we must look well after the spacing of our stay bolts, especially at the four corners of the fire box. We recently had some trouble in that respect, which was illustrated in some of the railroad publications. The stay bolts in the corners of the fire box were broken, but we overcame the trouble by putting in additional stay bolts in the corners. This included about five or six rows of stay bolts at the bottom and seven or eight rows up. By putting an extra stay bolt in between them we had no trouble afterward, showing the stay bolts were placed a little further apart in that part of the boiler than they should have been.

The wide fire box enables us to start out with, say, 3½ inches at the mud ring at sides, and the easy radius of the fire box proper to the outside shell enables us to have quite a space for water at the upper corner of the fire box, and enables us to have a good length of stay bolts at that point, the space at the front of mud ring being 4 inches.

With reference to the crown bolts, there are differences of opinion. Some favor the head underneath, which is very good,

but I have seen some very bad work from it, and unless it fits perfectly in the thread you will have a leaky bolt. Further, if the head of the bolt does not go up to the crown sheet (they just drive or calk in the edge), it is not very good work, but we get work that occasionally is tight. We like to put the bolts in the other way, and have the nuts on the crown bolts underneath the crown sheet. Our reason is that we notice, if there is trouble from carelessness of the engineer, getting short of water, that the crown sheet is easier to throw down when it gets to that heat, that enables it to do so with the stay bolts hammered over it, much better than with the nuts applied. The nuts seem to protect the sheet for a longer time, and probably in that space of time the water will get in and prevent the sheet from going down.

The flue holes should not crowd the flange too close, and the unions between the flues must be sufficient, and with 2-inch flues should not be less than 2¾ inches, the holes to be drilled in firebox flue sheet 1 15-16 and each end of flue sheet swaged accordingly. The fire box door should be long to facilitate the handling and cleaning of the fire. In other words, with a wide fire box, we found the round door does not give the fireman sufficient room to get at the corners, and we make the opening long enough to put in two doors on one frame, and this opening is long enough to enable the fireman to get at the corners well. I will add here that we seem to have more destruction than formerly when boilers were neglected by allowing them to get short of water. In other words, with the old engines, if they got short of water, the front end of the crown sheet would go down and tear it off the crown bolts to the extent of twenty-five or thirty bolts, and probably that would be the last of it, but with the present boilers the first thing you know they are flung out of the frames or the engine turned upside down. The consequence is that the crown sheets on our modern engines, chiefly, are level and the whole surface gets hot at the same time, and when anything happens down it comes, and if it has sufficient room to allow the reaction, there is trouble. In other words, if the crown sheet was tipped back, similar to the old ones, I think it would be a benefit to us. We do not lose much heat. The crown sheet, in my opinion, could be dropped at the back, say, three inches, so that the whole surface of the crown sheet will not be exposed at one and the same

time. Our old fire boxes were made in that manner, and the disaster was less, but we must not forget that the steam pressure was also lower.

By all means we should exclude the air from the side and end sheets, making all the air pass through the grate proper. The dome being low, it is necessary to have a throttle that will take steam as high as possible. The smoke box should be as short as possible to reduce the work to be performed in forming a vacuum. Some of the gentlemen spoke yesterday of the long 10-wheel connected, prairie type engine. It is necessary to have the long flue, 20-feet. In some cases the flue sheet is moved back, to keep it at that length. It makes a very long space from there to the center of the exhaust, and it makes a very long smoke box. As a general thing, we can not afford to have the smoke box too long. The shorter it is the better. The smoke stack is so very short that we find a straight one the most feasible to get along with. If the stack is long, we could control matters better, but with a short stack, from our experience, we have found the straight one better. You are not tied to a certain focus to strike the stack with the exhaust. It does not make any difference if you hit it near the bottom or at the center anywhere, as long as you fill it.

As to the question which is the best flue, I am always in favor of the 2-inch flue, for the reason you get more heating surface from the 2-inch than the 2¼-inch flue, but whether it is necessary to have the 2¼-inch flue for 20-foot flues is another question, but we get more heating surface from the 2-inch than the 2¼-inch flue.

There is another matter I was always in favor of, with the engines having a wide fire box, and which brings the engineer up on the side of the boiler, and that is, I consider it better to use a water column, putting the water column at a convenient place where he can get at it. In running there is not that very quick motion in the water column that there is in the glass put on the sides. The water is steadier, there is movement enough in it to know it is working, and the water keeps at a steadier height. There is one objection to that, the expense of it, and, furthermore, in working it, the engineer sometimes shuts off the angle cock — there are two of them, one at top and one at bottom, and we have found the cocks shut off so that the glass did not work. In the first

case, $25 is not very much expense to add to the boiler, if there is any benefit in it; and in the second case, if an engineer is on an engine and does not know his gauge glass is not working, the sooner he is taken off the engine, the better.

With these remarks, I will close by saying that I consider our modern boiler an ideal one for a locomotive.

THE PRESIDENT: The Chair dislikes to render an arbitrary decision, but this being our last day, a motion is in order to limit the discussion to a certain time-limit, and I would like some one to make that motion.

MR. PECK: I move that the discussion be limited to five minutes.

Motion seconded and carried.

MR. FULLER: I would like to ask Mr. Brown if his remarks have reference to the "Lackawanna" engines with the Wootten boiler equipped with the "D" flue sheet, or whether he referred to the Wootten boiler with the straight flue sheet.

MR. BROWN: We started with the Wootten boiler, but did not make many of them. We abandoned the combustion chamber, brick arch and taper leg. In other respects it is the same boiler, with a wide fire box. We have about four inches of what you may call a combustion chamber. The flue sheet and leg sheet are flanged.

MR. FULLER: Have you any trouble with the fire-box throat sheet checking or bulging in toward the fire?

MR. BROWN: We have had a little trouble with the throat sheet, but nothing to speak of; no more than we would have with the throat sheet of the fire box of a lump-coal burning engine.

MR. FULLER: I note in the report of the committee, Cut No. 3 shows a Central Railroad of New Jersey engine with a fire box having a "D" flue sheet. If there is a representative of that road present I would like to know if they have had any trouble with the fire-box throat sheet cracking or bulging in toward the fire?

MR. WILLIAM MCINTOSH: We do not use the "D" flue sheet to any extent on our system, although we have it on a few engines

and they are doing very nicely. With reference to the inside throat sheet below the flue sheet, we have no trouble with that at all. I imagine that the bulging spoken of results from using crow feet for stay connections; they gather encrusting matter and the sheets become very hot and bulge from that cause.

I want to say a word about tubes. In the first place, to get good results, the tube should be carefully set in the sheet. I think in a great many instances that is not done. They are driven in hurriedly and the setting is often done indifferently. In my experience we have found it advisable to use a very short ferrule, just long enough to pass through the sheet, or just as long as the sheet is thick, and when it is set it expands sufficiently to form a little grip on either side. Then fit the flues carefully and drive them tightly into the ferrule, and, instead of flanging the tube over immediately, good results have been obtained by upsetting it, having the man in the front end hold against the tube with a heavy mandrel and the one in the fire box, instead of turning it over, as is commonly done, upset the end with his hammer before beading it. This gives additional strength where needed, and we have been well satisfied by following that practice. When the tubes are well set the service they will give will be governed by several causes. For instance, if you have bad coal, the changes in temperature will be very pronounced and of frequent occurrence and that will have a tendency to interfere with the service of the flues. If you are using bad water, and there is rather a preponderance of that, especially in the western country, more damage will result to the bottom flues on account of their becoming more dense in the bottom of the boiler and absorbing the heat less rapidly than at the top.

With reference to the wide fire box not giving much trouble, with side sheets failing, I think that is somewhat owing to the fact that most of the roads running this type of engine use anthracite coal, and maintain more uniform temperature than in cases where bituminous coal is used. With bituminous coal, when a fireman is a little careless, he can let the temperature go up and down quite rapidly.

The greatest opportunity, however, to prolong the life of flues and fire-box sheets lies in the direction of improving the quality of the boiler feed-water before it enters the boiler. A liberal

be placed upon the conditions which are supposed to have prevailed during the time these observations were taken. As I understand it, fusible metals were placed in the tubes between plugs of asbestos, tightly driven. Under these conditions it has been assumed that no heat would reach these particles of fusible metal, except through the water of the boiler. Under such conditions, however, it has been found that the temperature within the tube rose 70 degrees higher than the temperature of the steam in the boiler, from which observation, as I understand it, it is concluded that the temperature of the water around the tube must have been at least 70 degrees higher than the temperature of the steam in the boiler. I do not think such a condition possible. The only thing which could allow such an increase in the temperature of the water around the tube would be a corresponding increase in pressure at that point. Of course, there is some increase in pressure around the tubes, due to the head of water above them, and there may also be some increase of pressure due to the head-equivalent of the frictional resistance which opposes the circulation of the water. The latter value, of course, must be very small, although the bubbles in the upward currents may be greatly crowded. Viewing the subject, therefore, as a purely physical proposition, it seems to me misleading to accept the results that have been quoted as indicating the actual condition within the boiler. It can not be, I think, that the water around the tube has a temperature anywhere near 70 degrees above the temperature of the steam in the boiler.

THE PRESIDENT: With regard to Mr. Van Alstyne's statement; the driving of plugs in the flue sheet, so that the heat from the fire box will not pass through them, has demonstrated to my satisfaction that we have solved the problem of leaky flues. After the water was excluded from that section of the flues, he was able to obtain a heat sufficient to melt the alloy. It melted at 450 degrees. As to the conditions which Mr. Van Alstyne mentions, any of us who watch leaky flues know it is true we can put a hammer handle in them and move them in the flue sheet. These same conditions exist when the boiler is low in water. If we plug a certain number of flues around the section of boiler that has leaky flues, and allow the water to reach the flues, we will

hood, where the tube numbers were lower than in the present practice. For that time the number would be about 150 flues, and would, therefore, give a space or bridge of about 5/8 for that number of tubes. We have engines running to-day with over 300 tubes, where the bridge is not more than 5/8 of an inch and there is no question in the mind of the thinker that this fact has a good deal to do with the lack of circulation in our boilers.

For clearance between tube and boiler shell the same authority recommended 1-16 of the diameter of the shell for the upper rows of tubes. This would make a distance of 4½ inches on boilers 72 inches in diameter. We have boilers of that diameter where the flues approach a great deal closer to the sheet than that, and its effect on the circulation is evident. Herr Von Borries, in recent tests, placed the limit of rate of evaporation at 14.5 pounds of water per square foot of heating surface per hour. This figure comes very close to known records and known results recently obtained here. He also places the limit of rate of combustion at 97 pounds of coal per square foot of grate surface per hour. We can get no such evaporation at that low rate of combustion. Combustion will amount to pretty nearly twice that figure for the high evaporation noted.

The object of my taking a portion of your time in this discussion is this: I think it is proper and meet that this Association should take some steps to demonstrate what effect a reduction of the number of tubes in a boiler would have; that is, to increase the center spacing — and that would mean a reduction in the number of tubes — to show what the result would be. These tests should be made both in the laboratory and on the road; the laboratory tests for refinements to show exactly what can be done, and the road tests to determine if actual practice confirms the expectation adduced by the laboratory tests.

Prof. W. F. M. Goss: I have been interested in the statements which have been made concerning temperature measurements, which Mr. Street, also, has just referred to, and I can not but think we are likely to be misled in our reasoning by placing too much dependence on the results which have been given. I do not doubt the accuracy of the observations which have been made, but I do somewhat doubt the degree of reliance which can

be placed upon the conditions which are supposed to have prevailed during the time these observations were taken. As I understand it, fusible metals were placed in the tubes between plugs of asbestos, tightly driven. Under these conditions it has been assumed that no heat would reach these particles of fusible metal, except through the water of the boiler. Under such conditions, however, it has been found that the temperature within the tube rose 70 degrees higher than the temperature of the steam in the boiler, from which observation, as I understand it, it is concluded that the temperature of the water around the tube must have been at least 70 degrees higher than the temperature of the steam in the boiler. I do not think such a condition possible. The only thing which could allow such an increase in the temperature of the water around the tube would be a corresponding increase in pressure at that point. Of course, there is some increase in pressure around the tubes, due to the head of water above them, and there may also be some increase of pressure due to the head-equivalent of the frictional resistance which opposes the circulation of the water. The latter value, of course, must be very small, although the bubbles in the upward currents may be greatly crowded. Viewing the subject, therefore, as a purely physical proposition, it seems to me misleading to accept the results that have been quoted as indicating the actual condition within the boiler. It can not be, I think, that the water around the tube has a temperature anywhere near 70 degrees above the temperature of the steam in the boiler.

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go a long ways toward solving the problem. We have twenty-five engines in service, which have been running thirteen years, hard work, with wide fire boxes, and none of these engines have had a fire box renewed. I believe if the space in the sheets near the top of the crown sheet is made wider, that will go a long way toward eliminating stay-bolt failures, so that the nearer the top the longer the bolt, we having found that less stay bolts are broken as they reach the top.

PROFESSOR HIBBARD: I would like to tell of some tests we made this spring regarding the effect of increasing temperatures upon the life of stay bolts. The reason why we started these tests was because it is a well-known fact that if you bend the metal or hammer it, or do anything else of the sort to it, while it is at the blue temperature, which is commonly considered to be the temperature between that of boiling water and that at which if you sprinkle hardwood sawdust on the metal it will ignite — we wanted to carry out some tests on stay bolts to see whether the increasing steam pressures up to three hundred pounds per square inch would cause the stay bolts to become more brittle, because of their being at the blue temperature, as we supposed. I had for some years imagined that the increasing pressures of modern boilers would cause stay bolts to be somewhere near the blue heat, and thus cause them to be more brittle and perhaps make stay bolts more likely to break as we increased boiler pressures. We rigged up a machine to test them, and we endeavored to come close to making the test correspond, in its various conditions, to the actual working conditions of stay bolts in locomotive boilers, namely, we took a thin piece of boiler steel and a thick piece, to represent the inner and outer sheets. We screwed a stay bolt into these two sheets and riveted it there, so it would be like service conditions. Then we immersed the stay bolt in a bath of hot oil, the temperature of which we controlled by a gas flame, and found its temperature by a thermometer, continuously, then put the stay bolt in it, the tension corresponding to the tension at the different steam pressures at which we wished to test the various stay bolts, and then vibrated the two sheets so that the stay bolt would bend 1/8 of an inch up and 1/8 of an inch down, like the tests commonly carried out on stay-bolt iron at Altoona. We furthermore fast-

ened the sheets in such way that the space for the stay bolt would be about four inches apart, taking that as a standard. Thus much for the description.

On testing the stay bolts at temperatures corresponding to atmospheric steam pressure, with a long jump up to 160 pounds of steam and then varying by small amounts of steam pressure up to three hundred pounds, we found what, to me, was a surprising fact, namely, that the increase of steam pressure, resulting in an increase of heat, did not cause the stay bolts to become more brittle as you increased the steam pressure, but caused them to be more ductile, just the reverse of what we expected. The moral I drew was this: That so far as the effects of increasing steam pressure in our modern boilers up to at least three hundred pounds per square inch, by gauge, on stay-bolt life, regarding its brittleness in its bendings, the area in which they always yield and break, the brittleness was decreased; the stay bolts endured a considerable increase in the numbers of bendings before they would break.

The President: I believe Mr. Fuller can substantiate the statement that it is possible, by excluding the water from a certain section of the flues to improve the matter of leaky flues.

Mr. Fuller: I am afraid that neither Mr. Brown nor Mr. McIntosh understood my question. What I want to ascertain is whether or not any of the members using Wootten boilers, having what we term a "D" flue sheet, have had any trouble with the fire-box throat sheet cracking or bulging in toward the fire? We have experienced considerable trouble with the fire-box throat sheet cracking and bulging; in some cases we have had to remove the fire-box throat sheet inside of a year. One case in particular that came to my notice, the fire-box throat sheet was distorted just below where the sheet is flanged ahead to take the flue sheet and extending each way from the center of the fire-box throat sheet 10 inches; the flue sheet had forced the flange of the throat sheet down about ½ inch. We found the sheet was badly checked. We then experimented in the use of the "D" flue sheet; instead of flanging the fire-box throat sheet with a short radius and right angle, we flanged the flue sheet and the throat sheet at a convenient slope, thinking possibly to overcome

the trouble, but it did not appear to give any better results. As we did not experience this trouble with that style of boiler using a straight flue sheet, we were led to the opinion that it was more a matter of improper circulation than anything else that was causing the trouble at this point; the sheet being at a high temperature and poor water circulation, bulging was the natural result. At one of our shops our foreman boilermaker tried an experiment to overcome the trouble by taking a piece of tank iron and fastening it to the barrel of the boiler, lengthwise of the flue, extending it up through the two central bottom flues and running it forward from the throat sheet about 20 inches. The sheet was somewhat bulged or checked before the application of this shield and the engine was in shop. Not long ago, my attention was called to the condition of the throat sheet and I could not see that it had deteriorated any since the application of the shield, but whether or not this shield had anything to do with extending the life of the throat sheet I am unable to say. But after our experience with the "D" flue sheet we have practically abandoned its use, owing to continual trouble, and have gone to the straight flue sheet. We have found that it practically made no difference what style or manner in which the throat sheets were braced with "D" flue sheet, we obtained the same poor results in the end.

MR. A. L. HUMPHREY: Since reading the report and listening to the discussion I have asked myself this question: What changes in our present methods should we make in order to overcome the trouble we have on our road, and which I know several other roads in the western country are experiencing, to overcome the trouble they are having with their boilers, not only leaky flues, but with cracked side sheets, leaky seams, and an endless amount of other trouble which I know a great many of the western roads have. We have had some very good suggestions, all of which are valuable; but what change is necessary to overcome the trouble we are having? In going over this question I have not thought of a suggestion, or heard a single suggestion, that will change the methods in vogue. If that is the case, we are going to continue with our present trouble. To illustrate the trouble we are having, and which is only one out of a great many, I will say that last August we bought ten consolidation loco-

motives of the so-called modern type. These locomotives were put in service between August and November. Out of the ten locomotives six of them have already received, or are receiving, new side sheets complete. There is one of these locomotives that has broken at least five hundred stay bolts in that period of time. The flues leak in proportion to the other parts of the boiler. We have tried every possible remedy that we know of. We have applied the flues in all the modern ways, have used all the care that is possible in maintaining an even temperature; and, notwithstanding that, the engines continue to bother us.

I have investigated the conditions in other parts of the country and when I get on the ground, or send an emissary, I find the same conditions prevailing. Notwithstanding all this, I have met a good many men at this convention who say they have a "little trouble" with their flues, but not much. I believe this Association can afford to be honest with the locomotive proposition. It is the most expensive part of the maintenance of a railroad to-day; it is expensive to the transportation department, and it is expensive in maintenance. That being the case, I do not believe that this convention could do better than to appoint a committee or retain the present committee, to prolong these investigations and researches, and that committee should be composed of members who could take time to visit the different parts of the country, and not depend on correspondence or reports. They should make these investigations where the bad water exists, where they are having the trouble, and not take reports from roads that are not having trouble, and then say, "Why, such and such a road is not experiencing any trouble, they have the same class of locomotives, why don't you pursue the same practice they do?" We do, we employ the most intelligent help that we can get, and still we are getting the bad results — I say "We," I mean roads that are having serious trouble with their locomotive boilers. I know there are parts of the Santa Fe system on which they are not able to get three months out of the side sheets. Still, I have talked with a gentleman since I have been here who speaks about getting seven or eight years out of the back and side sheets. They say they take care of the boilers. I know that the men who take care of the boilers in the western country are looking after the side sheets and boilers as carefully as the men who say they

get seven or eight years out of the boilers, and one man told me he had no trouble in getting thirteen years. Mr. Forsyth, of the *Railway Age,* has had some valuable correspondence, I should judge from the articles printed on this subject, and I believe it the committee was permitted to have possession of the correspondence it would throw a great deal of light upon the boiler trouble throughout the country.

I would urge, in conclusion, that this convention retain the Committee on Boilers, with instructions to prolong the research, giving the committee authority to draw on the Association for expenses and that part of the investigations shall consist in going to the different parts of the country to see the actual conditions. If no other report should come before this Association next year, and we could have a report on this subject which would throw light on it and give a reason for the trouble, and a remedy for it, it would be money and time well spent if we did not consider anything else.

MR. QUEREAU: I notice the Committee on Subjects recommends two subjects for committee work next year, which will cover the ground, I think. The third subject which the committee recommends for consideration at the next meeting is:

" Boiler tubes. What is the reason for the apparent increase of difficulties with leakage in the tubes of large locomotives? Is the present tendency toward crowding boilers full of tubes, in order to secure large heating surfaces, a good one? Should not more space be provided between tubes for the improvement of circulation — especially in bad-water districts? What is the cause and what the remedy for leaky tubes?

The eleventh subject is:

" Rapid destruction for side sheets in wide fire boxes and the reasons for it."

Assuming that the report of the Committee on Subjects will be approved, it occurs to me, in view of the large amount of important business to be transacted before this meeting closes, and the length of time that we have already given to this subject, important as it is, that the discussion should be closed; especially as there are others equally important yet to be considered at this meeting. I, therefore, move that the discussion be closed.

MR. D. VAN ALSTYNE: I would say one word with reference to Professor Goss' criticism of the experiment. I agree with him that the test is subject to criticism, but the manner in which it was made leads me to believe that there is some value in it. The tubes were plugged tight at both ends, and in addition to that these 18-foot flues were partitioned off with partitions 2 feet apart throughout the entire length, and the results given in the table were obtained. The tests, so far as the metal held out, which was about half way through the tube, were duplicated on another test and checked closely. I understand Professor Goss would assume that fire got around the plugs and melted the metal?

PROFESSOR GOSS: Possibly.

MR. VAN ALSTYNE: I rather doubt that, especially in view of the fact that the metal melted pretty near to the front end of an 18-foot tube. In regard to his statement that it seems incredible there should be such a temperature in that tube, I read in the *American Engineer* lately of a test that was made of temperatures of side sheets which is exactly in line with what I have noticed. They used globe valves, a row of them, up the side of the fire box, and ran pipes within an eighth of an inch of the sheet. When working the engine hard they could get nothing but blue steam. There is evidence that side sheets get red hot. We have found them very badly burned. When you break a piece of side sheet, cracked in service, by looking at the fire side through a microscope you will find sometimes it is burned. I do not see any reason why such high temperatures could not be transmitted through the narrow space between the tubes and melt the metal; whether it would be through the engine working so hard the tubes would be surrounded by steam, or the heat might be radiated through the water, I do not know, but I am inclined to think that these temperatures do exist.

PROF. W. F. M. GOSS: I wish it to be clearly understood that my statement is to the effect that I discount the experiments merely in so far as they are assumed to show that the water in the boiler had a temperature 70 degrees higher than the steam in the boiler. What Mr. Van Alstyne said concerning the temperature of sheets is another thing. I merely say that the water, as

water, could not have a temperature 70 degrees higher than the steam in the boiler.

MR. JOHN PLAYER: After listening to all this discussion and complaints of trouble from various members of the Association, I wish to reiterate what I said yesterday, that the whole trouble with the present locomotive boiler resolves itself into one of circulation after you have the means. If we do that, we will eliminate ninety-nine per cent of the present boiler trouble.

MR. CLEMENT F. STREET: I move as an amendment that the committee be continued for another year, and I would suggest that Professor Goss be made a member of the committee in order to carry on these investigations in regard to temperatures at the Purdue University.

MR. C. H. QUEREAU: I accept the amendment.

MR. WILLIAM FORSYTH: I would amend the motion that the present committee, if continued, have special instructions to make laboratory experiments with the object of finding out the principal cause of leaky tubes and cracked sheets, and the proper remedy; and also the proper spacing of tubes, and that the Executive Committee be requested to provide funds for paying any expenses connected with this work.

MR. HUMPHREY: In seconding that motion, I will suggest that Mr. Forsyth offer that as an amendment to the report of the Committee on Subjects, which I am sure will be satisfactory to them — it will be to me, as a member of the committee, and I should like to hear from the other two members if they are here — in place of their recommendations on the flue question and the side-sheet subject for next year. I will suggest that Mr. Forsyth's motion take the place of the regular report of the Committee on subjects in reference to this matter.

THE PRESIDENT: All these recommendations have to be submitted to the Executive Committee.

MR. FORSYTH: I intend what Mr. Humphrey suggests — that the two subjects on leaky flues and cracked side sheets, which are to be included in the subjects for next year, be referred to the present committee, with the addition of Professor Goss.

THE SECRETARY: The original motion was that the discussion be closed. Mr. Forsyth's motion is that the committee be continued to carry on investigations, and that the Executive Committee be authorized to provide funds to pay for it. Mr. Humphrey's motion was to consolidate the two subjects referred to by the Committee on Subjects. Another motion is to place Professor Goss on the committee.

THE PRESIDENT: We can settle these matters more satisfactorily if we pass the original motion which was made; and if necessary then make additional motions. The motions are in such shape it will be hard to vote on them all at once. You are familiar with the original motion.

(Question put and motion carried.)

THE PRESIDENT: We can now leave the matter in the hands of the Executive Committee and the Committee on Subjects, who will give attention to the suggestions which have been made.

Gentlemen, we have a very important matter here that I wish you would listen to.

THE SECRETARY: The Executive Committee last evening received the following communication from the representative of Joseph T. Ryerson & Son, Chicago:

Some time since we decided to offer this year three scholarships covering a four-year course in any institution affording a technical education that would fit the recipient for the management of a shop or manufactory using iron and steel.

In order to make these available to any ambitious and worthy applicant we decided to eliminate all cause for anxiety, from a monetary standpoint, by allowing each recipent $600 per annum with which to pay tuition and necessary expenses of living, feeling that this amount is ample to enable any right-minded and level-headed young man to become a mechanical engineer.

We have now assigned two of these scholarships and beg to offer to the American Railway Master Mechanics' Association the selection of the candidate for the third.

In asking your Association to coöperate with us in securing to some worthy young man an education we do not feel that it would be fair to hamper you by making unnecessary restrictions and will only require that this gift be known as the "Joseph T. Ryerson & Son Scholarship," and that the selection be made by you in time for the recipient to begin his course with the opening of the school year 1903.

The $600 per annum will be paid annually to your treasurer for four years to be disbursed as you may direct or under your instructions will be paid direct by us to the student.

In establishing these scholarships we hope that the amount set aside by us will be the nucleus of a large fund in the future, to be made up of contributions from those who have benefited, and while there will be no legal obligation to repay, we trust that all of those receiving an education under the terms of this agreement, will consider it a "debt of honor" to be returned if their circumstances permit so that others may benefit.

If your Association decides to honor us by accepting the responsibilities offered we suggest that in deciding on a candidate you require that he be:

First, a high-school graduate. A good education will be necessary to pass the examination to enter college.

Second, an employe in a shop coming under the jurisdiction of one of your members. This will give a certain amount of practical knowledge that we believe will be valuable and insures on the part of the member making the recommendations a knowledge of characteristics that could hardly be acquired in any other way.

Third, good health. A strong body will be indispensable to utilize the education. That you will carefully consider mental capacity and moral character goes without saying.

We have permitted the candidates selected by us to designate the school. You may do this, or if the plan you evolve for selecting the candidate makes it advisable, you may select the school.

Trusting that your association will decide to coöperate with us, we beg to remain,

JOSEPH T. RYERSON & SON.

The Executive Committee has referred this communication to the convention, for such action as it desires to take.

MR. C. H. QUEREAU: I was so fortunate as to be present when this proposition was presented to the Executive Committee by a representative of Messrs. Ryerson & Son, and I doubt if any one, except with the opportunity to think it over thoroughly, appreciates the significance of this offer, and influence of the example on others who are similarly situated — I refer to other manufacturing concerns — of the influence on this Association and mankind in general. It seems to me that this will result in a wide-reaching influence which can not help but be of benefit to all concerned. The example is a worthy one. I am particularly interested in one feature which impresses me — possibly I am wrong — and that is that a firm of manufacturers engaged, too, in what is commonly looked on as not the highest grade of manu-

facture, boilermaking, simply because of the class of work, should in this way confess their conviction that an education is a decided advantage to a man entering a manufacturing concern. It seems to me our Association has been highly honored in being offered this trust, and I would propose this resolution:

WHEREAS, Joseph T. Ryerson & Son have generously endowed several scholarships for worthy young men desirous of obtaining a technical education and have honored this Association by asking that we select one of the recipients; therefore be it

Resolved, That we accept the trust, pledging our best thought and coöperation, and that we hereby express our appreciation and approval of their generosity and aims; that the Executive Committee is hereby instructed to arrange the necessary details.

THE PRESIDENT: It seems to me that our past record could not have any stronger endorsement than what we have all witnessed here at this meeting — 110 new members, the Joseph Wheelock fund of $1,000, and now followed by a scholarship in any university in the United States as offered by Joseph T. Ryerson & Son. We can congratulate ourselves on our record.

The resolution was put to a vote and unanimously adopted.

THE PRESIDENT: The next business in order is the discussion of an individual paper on "Internal Combustion Engines in Railway Service," by Mr. R. P. C. Sanderson, S. M. P., Seaboard Air Line Ry. Company.

THE SECRETARY: Mr. Sanderson is not able to be present at this convention and he asked me if I would start the ball rolling, which I will simply do by reading an abstract of his paper. The paper is as follows:

INTERNAL COMBUSTION ENGINE IN RAILWAY SERVICE.

AN INDIVIDUAL PAPER BY R. P. C. SANDERSON, S.M.P.,
SEABOARD AIR LINE RY. CO.

(An Active Member of the Association.)

To the Members:

The manufacturers of gas and gasoline engines for pumps and coaling stations have, in the exploitation of their product, plentifully supplied the heads of the mechanical departments of railroads with abundant information with regard to the adaptability of such engines for pumping water, elevating coal and ashes, and for other similar uses.

In addition to this, many such installations have been illustrated in the technical press. Further, the energetic representatives of these man-

ufacturers have, naturally, taken the pains to see that all the heads of the mechanical departments of railroads are kept well informed concerning the possible usage of such engines for various purposes.

It would, therefore, be of very little interest to the members of this Association to reëdit and present to the Association in the form of report or paper, a lot of catalogued information and statistics concerning the use of gas and gasoline engines for such purposes; nor is it desirable to take up the time of the convention by giving a historical sketch of the development of the internal combustion engine from its early beginning through its many failures up to its present stage of partially complete development.

Fortunes have been lost in this process of development, and the partial successes and failures have been simply stumbling steps in the line of progress.

Had the internal combustion engine been invented before the steam engine, it is reasonably certain now that the latter would never have been developed and assumed the important standing in the industrial accomplishment that it has to-day, but the internal combustion engine would be in its place, doing its work and very much more efficient than it is to-day.

The mechanical genius of this country and Europe has, for years, been striving with really wonderful results to improve the efficiency of the steam engine, and when we compare the high pressure, quadruple expansion steam engines with surface condensers of to-day, with the long stroke, low pressure single expansion engines of fifty years ago, the coëfficient of efficiency tells the story of the progress made during that interval of time in perfecting the steam engine and boiler.

But, apart from the perfection of workmanship and design of the boiler, and the skill in making the engine develop the greatest amount of power with the least amount of steam, there are inherent losses in the process of converting the energy of coal or oil into power at the crank, which can never be eliminated in the steam engine and boiler. No boiler can be made which will absorb all the heat which can be given by the coal. There is a loss in the boiler due to the evaporation of water into steam, and other losses with which we are all familiar. The process itself is an extravagant and wasteful one.

To illustrate this, if we take an engine of reasonable efficiency in ordinary service (I do not now refer to the highest type of multiple expansion or condensing engines), with a reasonably good boiler, we can not expect to get a brake horse-power for much less than five or six pounds of coal per horse-power per hour.

In the present imperfect condition of the internal combustion engine there is no difficulty in getting a brake horse-power for one pound of coal per hour from producer gas, where nothing is wasted but the ashes, and, of course, some heat in the producer itself necessarily, due to the change of the carbon from its fixed form into that of fuel gas.

The internal combustion engine was more or less of a small affair,

and only used for light service with household gas or gasoline until the development of the great natural gas fields made available sources of power which were thought then to be inexhaustible, and justified the increase of size of and use of such engines, thus stimulating the development of the gas engine very much. Subsequently, when the gas fields began to give out, those who had used gas engines were unwilling to throw away their power and go back to steam, and cast around for artificial means of producing gas, and this had a good deal to do with the development of the gas producer.

Gas engines are now made not only in the size of toys, but up to 2,500 horse-power units. Formerly the waste gas from the blast furnaces was used in part for heating stationary boilers and furnishing steam to drive the blowing engines for the furnace. These boilers generally had to be supplemented with coal fuel to get enough steam to run the engines. Nowadays the steam boilers and steam engines have given place to powerful internal combustion engines, where the gas from the furnaces is burnt direct in the cylinders of engines and produces all power necessary for doing the blowing. A moment's thought of the immense saving this means in connection with the statement made above with regard to the possibility of producing power for anywhere from 1/3 to 1/8 of the amount of coal that is now being used for steam purposes in steam engines and boilers will indicate to the minds of members who wish to consider this matter what the possibilities are for the future.

In producing gas, one of the principal troubles and sources of expense of installation is necessitated for gas holders of large capacity to carry a sufficient supply of gas to meet the varying demands. Recent developments, it is understood, have made even this unnecessary, as gas producers, operating continuously, have been invented which furnish gas directly from the producer to engine, and which can be driven with varying capacity to satisfy the demands of the engine, just as a steam boiler is driven to meet the requirements for steam as demanded by the engine.

As gas producers will make good fuel gas from poor coal, without trouble from clinker, and as gas can be successfully used for every purpose in railroad service, not only for producing power, but also for doing work in the shop furnaces, for tinner's work, for blacksmith forges, for welding flues, for flanging and annealing boiler plates, for heavy forgings, for brazing, etc., it is quite practicable at any shop installation to put in a battery of producers, to turn the cheapest grade of slack coal into fuel gas. This can be used for driving individual shops or groups by gas engines located around the plant, if so desired, the gas being taken to them by piping, — for all smith shop and foundry purposes, etc., or, the gas engines can be located in the central power house and used to drive electric dynamos for power and light, the current being carried by wire to the individual machines or motors for group drivings.

In the West, and in many other parts of the country, where water is bad, where the cost of boiler work is heavy on account of incrustation and scale formation, and where the labor for boiler repairs is hard to

get and hard to handle, the use of gas power opens up possibilities of which it is believed progressive men will not be slow to take advantage.

A few years ago the horseless carriage was a subject for jest, and had never been a practical success. Now, nearly every street and highway in the country is more or less populated by automobiles of one kind or another. Perhaps the most successful ones are those operated by internal combustion engines. The stimulation which this industry has given to the development of the gas engine is not inconsiderable.

If the little gasoline engines can drive the heavy automobiles a mile in 52 2-5 seconds, which, I believe, is the best record so far, and if the machines can undertake trips of thousands of miles, it is proper to assume that they have become a permanent factor in transportation. What the final effect of this upon railroad passenger service will be, it is hard to predict.

As we all know, during the last two or three years of the present great industrial development, the coal supply has been insufficient. Vast as are the coal beds of the United States, the fact has remained that, due to first one thing and then another, we have all been struggling for a sufficient supply of coal. The prices have increased, due to the increased cost of production and the keenness of the demand, and it is likely that the cost will continue higher than it was a few years ago, and may go higher yet.

As the manufacturing industries and population of this country grow, the demand for additional power and for fuel for heating and lighting will steadily increase the demand for coal at the mines. Sooner or later we will be forced to take radical steps to economize in the consumption of fuel, which fact must be plain to all of those who can look ahead.

The internal combustion engine holds out the opportunity, and about the only opportunity there is in sight to accomplish this end.

Perhaps it is thought that the locomotive will always have to remain a steam locomotive. It is also believed that this is a field which the internal combustion engine will soon invade, and invade successfully. The inventive genius of the country will surely provide a means of building locomotives with continuous gas producers instead of boilers, and with the internal combustion engine instead of the steam engine underneath them. There is no question in the world but that this can be done, and successfully done with crude oil for fuel, and that such engines will operate for practically twenty to twenty-five per cent of the cost of fuel that is now necessary with the steam locomotive, that the boiler repairs will be practically eliminated from among railroad troubles, and is further believed that American genius will also find the way to successfully make gas producers acting continuously which will produce the volume of gas needed for heavy locomotive service as required by the engine without any need for storage.

The internal combustion engine has only recently taken a new lease of life: the great minds of the country have only recently set to work

to develop it. Its efficiency to-day can be compared with the efficiency of the steam engine fifty years ago; what its efficiency will be ten years from now can only be guessed, but it is quite likely that it will produce a brake horse-power ultimately for ½ pound of average grade of coal per hour.

With regard to fuel gas: The quality of this varies enormously, some gas having one hundred British thermal units, such as waste gas from blast furnaces used for blowing engines; and some gas having twelve hundred British thermal units per cubic foot, such as gas that comes from mineral oils. The richer the gas the smaller the engine required to produce the power.

It is quite likely that the future will see coal largely turned into gas right at the pit mouth at the mines, and either driven through gas mains to the sources of consumption or by gas engines of great power and dynamos there turn the energy of coal into electricity to be carried off to where power, heat and light are needed, by wire.

The above is presented to the convention as the result of several years of study and observation of this question in a general way, and with the hope that it may stimulate discussion and, perhaps, lead some active minds, who have the opportunity to do so, to assist along the good work, and, perhaps, vaguely indicate the way to some quick-witted inventors toward further progress.

THE PRESIDENT: The subject is now open for discussion. I understood from Mr. Soule that he had arranged for some one to say a few words on his part.

MR. C. H. QUEREAU: I have the honor to present Mr. Soule's remarks. He was called away and asked that I read this:

In this paper Mr. Sanderson certainly does not overstate the performance and the possibilities of the gas engine, but there are some indications, however, that he does fail to give the steam engine credit for the best performance of which it is capable. For instance, he says: "If we take an engine of reasonable efficiency in ordinary service (I do not refer to the highest type of multiple expansion or condensing engines), with a reasonably good boiler, we can not expect to get a brake horse-power for much less than five or six pounds of coal per horse-power per hour. In the present imperfect condition of the internal combustion engine, there is no difficulty in getting a brake horse-power for one pound of coal per hour on producer gas."

It will be noticed that Mr. Sanderson practically says that ordinary engines, such as are to-day used in railway power plants, can not be operated on a coal consumption of less than five pounds per horse-power per hour. Let us apply this to the case of Collinwood. According to the technical papers the stationary engines in the power plant are horizontal cross-compound and non-condensing. They are guaranteed to use not

over 19½ pounds of steam per horse-power per hour. If we assume for the boilers an evaporation of eight pounds of water to one pound of coal, and if we assume an efficiency of ninety per cent for the engine in transmitting power from its cylinder to its shaft, and again assume ninety per cent efficiency in the electric generator itself, we have a combined efficiency of eighty-one per cent for the engine and generator considered as a unit. Applying the figures reached by these assumptions it is at once shown that at Collinwood under the guarantee power is delivered at the switchboard (corresponding to Mr. Sanderson's brake horse-power) on a consumption of three pounds of coal per horse-power per hour as against the minimum of five pounds quoted by Mr. Sanderson.

Similarly and later on in the paper Mr. Sanderson says that a given amount of power can be produced by the gas engine with anywhere from one-third to one-eighth of the amount of coal required to produce the same power by a steam engine. Judging from all the reports of gas engine performance that have appeared, it appears very doubtful whether the gas engine can produce a certain amount of power with less than one-third as many heat units consumed as are consumed by the steam engine under the same conditions.

It is also rather surprising that gas fuel can be successfully used for blacksmith forges and for all smith shop and foundry purposes. It has been supposed that a bed of fuel was an essential for the operations carried on in blacksmith forges, and it will be counted a great advance if gas can ever be used for these purposes.

Later on Mr. Sanderson, being an Englishman, tells us how many British thermal units there are in the different varieties of fuel gas which are available. We suppose that these so-called British thermal units must be identically the same things as we would prefer in this country to call American heat units. Dr. Luckey, the Columbia College gas engine expert, recently said before the Central Railway Club:

"Gas for gas engine use varies in heating power from ninety to one thousand American heat units per cubic foot." In this connection it may be stated that Mond gas now produced and used so largely in England for power purposes, has an average calorific value of about 140 heat units per cubic foot. On the other hand, a recent installation of gas engines in the Keystone Bank building, at Pittsburg, is said to be using natural gas which has a calorific power of about 950 heat units per cubic foot. It would, therefore, seem that a very convenient rule for memorizing would be that the calorific value of such gas fuels as are ordinarily available for power purposes may be considered as ranging from a minimum of one hundred up to a maximum of one thousand heat units per cubic foot.

Whenever the relative economy of gas engines and steam engines is being considered for a given installation the first and most important thing to be ascertained is the exact calorific power of the fuel gas which is to be used. As is seen from the foregoing this may vary in a ratio of ten to one and is a fundamental and important factor in taking up a problem of this sort.

THE PRESIDENT: We have a great deal to do and I hope you will be prompt in expressing yourself on this subject or any other that is brought before us.

On motion, duly seconded and carried, the discussion was declared closed.

THE PRESIDENT: The next business in order is the individual paper on the "Metric System," by Mr. Angus Sinclair. It is as follows:

AN INDIVIDUAL PAPER ON THE METRIC SYSTEM.

BY MR. ANGUS SINCLAIR

(Treasurer of the Association).

To the American Railway Master Mechanics' Association:

The metric system is receiving renewed attention because of the following bill for its adoption which was favorably reported to the last House of Representatives by the Committee on Coinage, Weights and Measures:

"Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, that on and after the first day of January, 1904, all the Departments of the Government of the United States, in the transaction of all business requiring the use of weight and measurement, except in completing the survey of public lands, shall employ and use only the weights and measures of the metric system, and on and after the first day of January, 1907, the weights and measures of the metric system shall be the legal standard weights and measures of and in the United States."

Because of the shortness of the session the bill was withdrawn by its friends but with the expressed determination of reintroducing it and pressing it to passage at the session of the coming winter.

The importance of the subject to the railroad interests of the country seems to demand that it be given some attention by this convention.

At the December, 1902, meeting of the American Society of Mechanical Engineers a very exhaustive paper on this subject was presented by Mr. F. A. Halsey, which paper was followed by an unusually full discussion by the friends and opponents of the system. A careful examination of this paper and discussion justifies the following conclusions which are drawn by its author in closing the discussion:

1. If the system be adopted by this country the transition period will last for many decades and probably for a century.

This conclusion is based on a very complete inquiry and a mass of testimony from original sources which shows the extent to which old units are used in nominally metric countries. Even in France after more

than a century of the metric system the old units are still in wide use and the same is true of "metric" countries generally.

2. The adoption of the system in mechanical work involves the discarding of all existing mechanical standards.

To this Association, whose entire life has been devoted largely to the establishing of standards, this, of course, is the most important conclusion of all. The conclusion is based chiefly upon the actual workings of the system. As is well known, Germany uses Whitworth screw threads almost exclusively, and *she measures them just as we do — in inches.* In other words, in order to preserve English threads, Germany has been compelled to retain the inch as the unit for their measurement. In the Willans and Robinson engine works of England, which some years ago adopted the metric system, the old sizes are still made and measured throughout in inches, as screw threads are measured for both old and new in inches. In other words, in this "metric" shop, the inch is retained for measuring English sizes and standards, just as we must retain it if we are to preserve our standards. Again in such American shops as have made use of the system, the discarding of English sizes and standards has been in exact proportion to the discarding of the inch. The experience of the world may be summed up in a general law: *Wherever and to whatever extent the inch has been retired, to the same extent have sizes and standards based on the inch been abandoned.*

Dr. Stratton, director of the National Bureau of Standards and leader of the metric movement, is on record as saying before the House Committee: "A change to the metric system of weights and measures would undoubtedly bring about in time a change in our system of screw threads." The question is: Will existing standards compel the retention of the inch or will the millimeter compel the discarding of existing standards? Personally I believe the former, but the recklessness of those having this matter in charge is indicated by the public avowal of their expectations to the contrary. This prediction alone, *from the highest American metric authority,* should be enough to cause this Association to condemn this movement.

3. The prosperity of foreign trade does not require the adoption of the metric system.

This conclusion is based upon the growth of American export trade during the past few years — a growth which is unexampled in the history of the world. The testimony of many exporting manufacturers is also given to the effect that in this trade there has been no call for their goods to be made in metric units.

4. The bill is compulsory as regards all who do business with the Government.

This conclusion is evident from the wording of the bill.

A considerable number of scientific and educational societies and one or two civil engineering societies have passed resolutions in favor of the system and have thus created the impression at Washington that the sentiment of the country is in its favor. Under these circumstances it seems

proper that this Association should pass resolutions which will express the sentiments of the members and the following are offered for that purpose:

WHEREAS, A bill for the adoption of the metric system in the departments of the Federal Government has been reported favorably to the House of Representatives;

WHEREAS, We consider that the only effect of such a law will be the creation of a Government metric system and the continuation of the existing system in ordinary commerce and industry;

WHEREAS, It is evident that the confusion resulting from such a condition of things would be intolerable;

WHEREAS, We believe a change in the system of weights and measures used by the people at large to be impossible, therefore be it

Resolved, By the American Railway Master Mechanics' Association in convention assembled that we condemn all legislation intended to promote the adoption of the metric system in this country.

Resolved, That we especially condemn the bill which was reported to the last House of Representatives as one which can do nothing but introduce confusion where we now have uniformity.

Should the convention desire to make any changes in these resolutions, one change in particular should be guarded against. It is natural to draw up resolutions condemning compulsory legislation. Unfortunately, as matters stand, such resolutions are a little worse than none. While this bill is undoubtedly compulsory as far as it goes, its sponsors insist that it is not and have apparently made themselves believe it is not. Under these circumstances they simply say that resolutions against compulsory legislation do not apply to their bill, which they will thus go on and pass regardless of such resolutions. The only resolutions that can have any effect are those condemning this and all similar bills.

It is of doubtful expediency to vote against the provision of the bill which makes the system the legal standard. This only makes it the standard of reference and does not compel its use. Moreover it is expected to be eliminated or modified this fall and a vote against it will be a shot in the air. The really objectionable features are those which are intended to pave the way for the general introduction of the system by compelling its use by all those who deal with the Government.

MR. ANGUS SINCLAIR: Mr. President: The American Railway Master Mechanics' Association, in combination with the Master Car Builders' Association, has done about the most valuable work performed in the country in the introduction of the standard screw thread. The introduction of that system has been of immense value to railroad companies and to manufacturing companies generally, and anything that is to interfere with the great work by these and other associations should be looked at with great suspicion, and when it is understood to be a fight

against the system it should be opposed as thoroughly as can be done. For the last twenty years certain parties have been striving to introduce the metric system, which requires entirely new measurements that are not suitable for the subdivision of the inch. Consequently, if the metric system is adopted it will be necessary to make a rearrangement of the screw threads. That would cause so much confusion to railroads that I think it is the duty of all mechanical departments of railroads to oppose it as thoroughly as they possibly can. It is on account of that that I have brought this paper before you.

A bill will be before the next Congress to make the metric system practically compulsory. The advocates of it say it is not really compulsory, they are going to introduce it in the Government service and by that means introduce it gradually. The effect of that would be that we will have a dual system in the country, the manufacturers and railroad people will hold on to their inch measurement and the Government officials will be compelled to change to the metric system, no matter what the cost may be, and there will be a dual system running, with all the expense following, which we can easily imagine.

The difficulties of adjusting the inch screw threads to the metric system can be understood when we know that in all shops in Europe and in South America, where the metric system is in use, they use the inch system for the measurements of threads. Everything connected with threads is arranged according to the inch system. They have a dual system there and I do not think it is desirable that railroad shops should have to enter into that course of confusion. Therefore, I propose the resolutions, as offered herein.

Mr. Quereau: I move the adoption of the resolution.

Professor Hibbard: I most certainly hope that this convention will not go on record as planting itself on the seashore at low tide and say that tide shall not advance. I think it will be a great mistake if this convention should go on record with anything of this sort. It seems to me it would be best if these resolutions were not passed. I have read the arguments pro and con on this subject in the transactions of the American Society of Mechanical

Engineers. It is very amusing to read of some of the objections that are made to the metric system.

What is the metric system any way? It is only a decimal system. How many of you would like to go back to the system of pounds, shillings and pence? When I got on the steamship at Philadelphia, in 1900, to go to the other side, I thought my great difficulty would be in understanding their system of coinage, and so I got hold of the ship's purser and obtained samples of the various coins of England. I fastened each one of them on a piece of cardboard and wrote on the piece of cardboard how much each one of them was worth in American money. Then I got a table, so many pence to a shilling, so many shillings to a crown, so many something else to a pound, and a guinea was so big, and I studied the thing and got my wife to hand me a piece of money and ask me how many of these I would pay for a pair of shoes and not get cheated, and I got the thing all confused. The English people use the same arguments against going to a decimal system of coinage like our very simple dollars and cents, that the people who want to stand in the path of progress do toward the metric or decimal system. I do not think we ought to stand in the path of progress of something that is so much more simple than our present feet, yards, inches, lines, rods, miles, pounds, short tons, long tons, and a lot of other mixed up things like that. These are even more badly mixed up than the English coinage, only that we are used to them, because we have been using them so long. I hope these resolutions will not be adopted.

MR. P. H. PECK: I endorse the resolutions of Mr. Sinclair. We have a good many hundreds of thousands of workmen in this country, and we do not want to be compelled to give them cards. These men are paid by the hour; we do not want them to study cardboards; it is bad enough for them to study blue-prints. We do not want any mistakes made in our system. The move of a point of a decimal, in the metric system, would make a great mistake in the figures. The introduction of this system would require that we should educate the workmen all over again and change all the blue-prints. We would be going back to a past age.

MR. SINCLAIR: I want to explain to Mr. Hibbard that the American Railway Master Mechanics' Association is on record

against the metric system. The Association passed a resolution four or five years ago opposing the introduction of the metric system and the Association is now merely following up that action by opposing the measure now in Congress.

MR. JOHN PLAYER: I do not think this Association, which represents a large part of the mechanical brains of the country, especially in railroad work, should go on record as being opposed to the metric system. We must not be selfish. The decimal system is bound to come; it is a matter of destiny. We have it in coinage and everything else. I think an amendment should be added to the resolution to the effect that, while we do not approve at the present time of adopting the metric system as a whole, we do advocate some decimal system of weights and measures. I have had shop experience with both, the duodecimal system, which we unfortunately labor under, and the metric system, and the metric system went into use very gracefully.

MR. QUEREAU: I will say just a word. This resolution is not opposed to the metric system. If that system is all that its friends assume or claim for it — and assuming that it is, we are not combating the idea at all — the question is as to whether it should be made compulsory or not. The bill before Congress seems to be an entering wedge to make it compulsory. If it has the merit claimed for it, it will win its way. Do not compel us to adopt it. The resolutions are directed against the bill and not against the system.

The resolutions were adopted.

THE PRESIDENT: The next business in order is the discussion of topical subjects. We will first take up the paper on "Light for Locomotive Headlights," by Mr. William McIntosh, of the Central Railroad of New Jersey.

MR. MCINTOSH:

It appears that of the 41,300 locomotives in the United States, fully 37,450 of them still retain the oil lamp and ordinary planished reflector for headlights.

About 3,200 have electric headlights, using the ordinary reflector, and generating electricity with small steam motors of the reciprocating or turbine type — the latter rapidly coming into favor.

There are some 1,650 acetylene generators now in use for generating gas for locomotive headlights, which are mostly equipped with the regulation sheet-iron case and planished reflector — the remainder with what is

known as the "Lens Mirror" or "Searchlight Reflector," which is much smaller than the planished reflector, and vastly more powerful and reliable, occupying a much smaller casing, which is usually formed cylindrically, and therefore, much more compact and durable.

The reflector itself being of glass, and practically indestructible, requires only occasional wiping off to be in condition for service indefinitely.

It would seem probable that with these advantages it should soon succeed the old type of lamp.

The old oil lamp when compared with the new types of acetylene and electric headlights, costs much less for its supply of oil than the others do for carbide or steam — yet when the costs of operating it are counted carefully, including cleaning material, wicks, chimneys, and burners, with the frequent losses from burning up, it does not prove to be so economical after all; and it falls far behind in the candle-power of either acetylene or electricity, and failing also in entire reliability.

Acetylene gas, while costing more for its carbide than oil, does not require chimneys, nor expensive burners with wicks, and gives out several times the candle-power of the best type of oil-burning headlight, without bringing out criticism of its intensity.

The electric headlight is more expensive in the line of first cost; also in maintenance, owing to a motor and dynamo being required to generate the current, and the amount of steam needed to operate it. The intensity of the light thrown out is objected to by some on account of the glaring properties, and tendency to affect the vision of engineers approaching it; while others claim that these features are not seriously objectionable, and the advantages far outweigh them.

I give below some data regarding cost of maintaining the oil lamp in comparison with the electric and acetylene, there not being much information of this kind available.

One road reports the cost of maintaining 450 engines with ordinary headlights for a period of one year as follows:

Name of Parts.	Number of Parts.	Total Cost.	Average Cost per Engine.
New Headlights, complete	63	$1249.50	$2.76+
New Interiors	36	408.00	.91
New Burners	138	293 70	.65
New Cases	6	7.00	.02—
Reflectors replated and repaired.	268	815.54	1 81+
Buttons and other small repair parts	....	55.00	.12+
Chimneys	6396	533.00	1.18
Wicks	1056	21.56	.05
Glasses	204	91 71	.20+
Cleaner (Boxes)	1074	208.80	.46+
Labor and material, repairs	....	286.66	.64
Grand Total	....	$3970.47	$8 82

The above road reports the comparative cost of operating oil and acetylene lights, so far as the light-producing medium is concerned, as below:

With kerosene oil, at 7⅝ cents per gallon in tank lots.
With carbide at 3¼ cents per pound in 100 pound lots.
With cost of oil light per hour, 33-100 cent.
With cost of acetylene light per hour, 58-100 cent.

In presenting this statement it was suggested that a considerable saving could be effected by substituting the acetylene for the oil headlight, because of the possibility of eliminating a number of extras used in connection with oil lights and not required with acetylene.

Replating reflectors	$ 815.54
Buttons and other small parts	55.00
Chimneys	533.00
Wicks	21.56
Cleaner	208.80
Total	$1,633.90

Another road reports tests covering oil, acetylene, and three different types of electric headlights as shown in the total below:

Cost of kerosene, 14½ cents per gallon.
Carbides, 5 cents per pound.

Kind of Light.	Cost per 1000 Engine Miles.	Relative Value of Light.
Coal Oil	.1844 Ct.	1
Acetylene	.4688 "	8
First--Electric	.2821 "	50
Second "	.7109 "	50
Third "	.2533 "	50

This comparison is made on the basis of sixteen hours light per one thousand engine-miles.

In summing up, it is apparent that the oil-burning headlight has had its day, and must give way to better devices.

It is an awkward affair at best, with its large housing shaking loose, and front glass that is often breaking.

Its abnormal capacity for using up chimneys, and wicks.

The frequency of reburnishing the reflector.

The number of leaks that occur in its attached oil reservoir and connections.

The fires that often develop, resulting in the burning up of the entire apparatus.

The care required, in the way of trimming and cleaning; all combine to add to its unpopularity.

In former days when every locomotive, like Goldsmith's rood, maintained its man, or regular engineer, the oil lamp received the care and attention required to keep it in serviceable condition; but in these days of pooling and double crews, it is neglected, and generally presents a dilapidated appearance.

It will be claimed, and truly, that the acetylene and electric lamps also require attention and renewals; but if supplied with "Lens Mirror Reflectors," of the regulation diameter, and correspondingly small housings, which can be constructed on cylindrical lines, and largely of malleable or cast iron, furnishing the rigidity and endurance required, much better results should be obtained.

The relative cost of the different types of headlights might be approximated at $25 for the oil lamp, $100 for acetylene, and $200 for the electric.

Careful records will show that but little, if any, economy will follow the use of the oil lamp, while the efficiency is largely in favor of electric or acetylene.

THE PRESIDENT: Is there any discussion on the paper which Mr. McIntosh has read? If not, we will proceed to the next business.

THE PRESIDENT: We would now like to have the report of the special committee on grab irons.

Mr. Purves presented the report, as follows:

To the Members:

The committee appointed to consider the application of grab irons or hand holds to the front end of locomotives and rear end of locomotive tenders begs to call the attention of the Association that the Safety Appliance Act as amended March 2, 1903, and taking effect September 1, 1903, is made to apply to all trains, locomotive tenders, cars and similar vehicles used on any railroads. The committee respectfully recommends that the rear of locomotive tenders be equipped with grab irons to conform to the M. C. B. standard of equipping flat cars. The law makes it necessary that pilot couplers be made operative without the necessity of trainmen going between the locomotive and car. This makes it necessary to devise some method of operating the pilot couplers from the outside; as there is a great diversity of the arrangement and application of pilot couplers, the committee is unable to recommend a standard method of application, but as we are confronted by the law it is absolutely necessary that some action be taken at once in the premises. A full discussion of this very important subject is desired.

T. B. PURVES, JR.,
C. E. FULLER,
P. H. MINSHULL,
Committee.

The President: What action will you take upon this report?

Mr. P. H. Peck: I move that we adopt the recommendation of the committee referring to grab irons on the rear of locomotive tenders, and that we report another year on the front end grab irons.

Mr. P. H. Minshull: The law requires the engines to be equipped by the first of September, 1903. Something has to be done at once, and we do not think it possible to get out a standard, but we would like to have a discussion with a view to bringing out the opinions of the members to enable us to get something which will be satisfactory.

Mr. Peck: I do not think the law covers pilot couplers. It refers to tenders.

Mr. Fuller: In talking with the chief inspector of the Interstate Commerce Commission the subject came up relative to the pilot or front end of engine. The wording of the law does not explicitly say anything about the head end of the engine, except that it says that the couplers on the engine and tender must be operative, and the Commissioner gave it as his opinion that the spirit or intention of the law was that the coupler on the head end of the engine, as well as the tender, should be operative from the outside to avoid the necessity of going in between the pilot and car in coupling or uncoupling. From the information obtained from the members of the Interstate Commission, I am led to the opinion that it is necessary for us to make our couplers operative on both ends of the engine and apply grab irons to the bumper beam on the head end as well as the beam on the rear of the tender frame.

The President: I believe this matter could be referred to our management and they would have influence enough with the Interstate Commerce Commission to show them the propriety of not enforcing the law at the present time. I believe it is recognized that uniformity in all our safety appliances is a most important thing, and if our management went before the Interstate Commerce Commission and showed them the impropriety of forcing us to put something on which had not been properly developed, thereby increasing danger rather than diminishing it, this matter

could be postponed. We had no trouble in having the coupler law and air-brake law extended, and I suggest that some one move that this matter be referred to the management to take up with the Interstate Commerce Commission to see if some postponement can be had until we have had time to make proper provision for these grab irons.

MR. H. T. BENTLEY: The Chicago & North-Western Company has taken hold of the matter in the same way as at the rear end of the tanks and put on a rod that goes from one side of the pilot beam to the coupler and covers the law exactly. We do not have any trouble in coupling with this arrangement, and I do not see that there would be any difficulty in doing that on all roads.

MR. FULLER: The Secretary has on his desk some blue-prints showing the proposed application of the uncoupling device on pilots of our engines and if any of the members care to look at these prints they now have the opportunity.

MR. SELEY: It seems to me, in view of the relatively greater importance of the grab iron on the rear end of the engine than on the front end, that the Association can well consider the recommendation of the committee and put on grab irons in accordance with the M. C. B. practice on platform cars and not depart from standard practice. I think, however, the front-end affair is an entirely different matter which could be carried to our managements if the law is to be construed to apply to the front end as well as to the rear end. I do not understand that it does. I will make a motion that the recommendation of this committee, in regard to the application of grab irons on the rear of the tender in the manner specified for platform cars, be adopted.

MR. QUEREAU: I would amend the motion to include that the matter of the front end be referred to our management with the idea of getting an extension of time from the commission, as we consider it very important that there be standards adopted for the grab irons in question so that there shall be less danger.

The motion, as amended, was carried.

THE SECRETARY: Several years ago this Association passed a sort of blanket resolution relating to various societies, but which had more particular reference to the Traveling Engineers' Asso-

ciation, giving them recognition from the American Railway Master Mechanics' Association. The International Railway Master Boiler Makers' Association, at their convention a few days ago, asked that the American Railway Master Mechanics' Association assign two or three subjects to them for investigation, and also requested that they be put on somewhat the same basis as the Traveling Engineers' Association, that is, be recognized in a somewhat similar manner. The Executive Committee at its meeting on Monday night thought the matter of assigning subjects could better be attended to by that association than this; that it was entirely in their province to furnish subjects for themselves and report upon them; but the Executive Committee did believe that it would be proper for this Association to recognize the International Railway Master Boiler Makers' Association.

MR. P. H. PECK: I move that we advise the President and Secretary of the International Railway Master Boiler Makers' Association that the American Railway Master Mechanics' Association endorses their work.

The motion was carried.

THE PRESIDENT: The next business is an individual paper on "Effect of Tonnage Rating Upon Cost of Conducting Transportation," by Mr. C. H. Quereau, Supt. Shops, N. Y. C. & H. R. R. R.

MR. C. H. QUEREAU: I will simply read the summary of the report, assuming that the members have all read the paper. The paper in full is as follows:

AN INDIVIDUAL PAPER ON EFFECTS OF TONNAGE RATINGS ON THE COST OF TRANSPORTATION.

BY C. H. QUEREAU, SUPT. SHOPS N. Y. C. & H. R. R. R.
(An Active Member).

To the Members of the
American Railway Master Mechanics' Association:

For some time before the ton was substituted for the car, as a basis for loading freight engines, the fact that the car was an unsatisfactory unit was recognized by those who gave the subject careful attention. It required but little investigation of the cases of stalling and doubling and unsatisfactory runs to develop the fact that a considerable proportion of these cases were caused by overloading, because of an unusual proportion of

high capacity cars. This called attention to the fact that the car, as a unit of weight and resistance, was a variable quantity with a constantly increasing value, so that, though the engines were nominally given the same train, it more and more frequently happened that they were loaded beyond their capacity, resulting in annoying and expensive delays.

The cause of the difficulty having been determined, it naturally followed that a unit of constant weight, the ton, was substituted for the car. Notwithstanding the almost self-evident correctness of the facts and reasoning which resulted in the use of the ton as a rating unit, there was a quite general opposition to its adoption on the grounds that, though correct in theory, it would not work out in practice; the conductors and yardmasters already had too much to do without being burdened with more clerical work; the extra expense would more than offset the savings; or the trouble lay with the train and enginemen instead of the ratings.

It is related that the first steamship to cross the Atlantic brought, as a part of its cargo, a book which demonstrated beyond a doubt that no vessel could carry enough fuel to make the trip. Likewise, while the conservatives contended that the car unit was satisfactory, good enough, and the substitution of the ton as a unit of engine ratings would prove no better, the advocates and users of the more scientific basis secured fewer and shorter delays and cases of doubling, less overtime and more uniform time between terminals, till it has been practically universally admitted that the use of tonnage ratings has materially reduced operating expenses.

The superiority of the ton to the car as a unit of train rating is due not so much to the fact that it has a constant value as a unit of weight, as that it is a much more accurate measure of train resistance. Soon after its adoption the discovery was made that the ratio between train weight and train resistance is not constant, which led to a scientific investigation of the facts by means of dynamometer car tests. These showed that the greater the gross weight per car, the less the resistance per ton; that the heavier the adverse grade and the slower the speed the less this difference is. For example: It requires considerably less power per ton to haul a loaded fifty-ton car than a loaded twenty-five-ton car; at a speed of twenty miles an hour, on level track, a ton of empty car has a resistance fifty per cent greater than a ton of loaded car, while on a one per cent grade, at a speed of ten miles an hour, the ton of empty car develops only about seven per cent more resistance than a ton of loaded car. These discoveries led to the adoption of adjusted tonnage ratings, which increase the nominal weight of empty, partly loaded and low capacity cars in proportion to their resistance per ton, so that the adjusted ratings much more nearly approximate the resistance a train will develop than though the actual weights were used. There is little room for doubt that this refinement of the original plan of tonnage ratings has resulted in still farther reducing transportation costs.

There have been indirect savings in operating expenses, due to the use of tonnage ratings, which are not always considered. I refer to the

use of the ton-mile basis for statistics, which naturally followed the introduction of tonnage ratings. Previously the almost universal basis of motive power statistics had been the engine-mile. Because the engines made more miles per ton of coal the lighter the train, there was a constant effort on the part of Master Mechanics and engineers to haul as light trains as possible in order to improve their records, which no doubt in a measure neutralized the efforts of the transportation department to handle as heavy trains as possible, and undoubtedly increased the cost of transportation somewhat, when compared with the possibilities, and was a source of constant friction between the two departments. The ton-mile basis for motive power statistics changed all this, because it was soon demonstrated that the heavier the train, within reasonable limits, the less the cost of coal, wages and repairs per ton-mile, and, therefore, it was to the interest of the motive power men to haul as heavy trains as practicable, thus harmonizing the interests and efforts of the employes of both the transportation and motive power departments. It would be impossible to say just what economy was produced by this change in the basis of motive power statistics, but that it was real and considerable in gross amount there can be no doubt.

The ton-mile basis also corrected a number of erroneous conclusions, resulting in a clearer understanding of cause and effect, which no doubt led to economies. A few illustrations will probably make this point plainer than an extended description. The figures given are actual records.

TABLE I.

	March, 1896.	1897	Increase Per Cent.
Average miles per engine..........	2,282	2,289	0.3
Average ton-miles per engine......	782,213	972,486	24

Had there been no ton-mile statistics, there can be little doubt the conclusion would have been drawn that the average work done per engine, in the two years, was practically the same. The ton-mile figures show this conclusion would have been wide of the mark and misleading, and also demonstrate that in this case the use of tonnage ratings increased the work done by the engines twenty-four per cent, as the class of locomotives was practically the same in the two years.

TABLE II.

DIVISION D — JANUARY, 1896.

	Miles to Ton of Coal.		Coal per 100 Ton-miles.	
	Lbs.	Per Cent.	Lbs.	Per Cent.
Main Line, Freight................	16.6	100	20.79	100
Branch, Freight......	14.8	112	67.93	327
Main Line, Freight................	16.6	193	20.79	100
Main Line, Passenger............	32.1	100	33.09	159

Judged by the results on the engine-mile basis, the branch freight engines were using only twelve per cent more coal than those on the main line. This record was considered very satisfactory indeed, so far as the branch was concerned, as there were a considerable number of heavy grades and curves on it, while the main line was comparatively level and straight, and the conclusion was naturally drawn that it was not much more expensive, so far as fuel was concerned, to operate a mountain district than one on the prairie. But as soon as attention was directed to the figures based on the ton-mile it became evident that the heavy grades and curves of the branch required three and a quarter times as much coal as the main line to do the same amount of work.

In comparing the relative cost of fuel in freight and passenger service, using the engine-mile as a basis, the almost inevitable conclusion was that freight engines used nearly twice as much as passenger engines, but when the basis of comparison was the ton-mile, it became evident that the cost of fuel was practically sixty per cent greater in passenger service.

It would be impossible to show the saving resulting from these discoveries, but there is little room for doubt that there were economies growing out of a more accurate knowledge of the facts in the case, a more intelligent reasoning from causes to effects and a conviction on the part of all concerned that the results were being studied and conclusions drawn on a fairer basis than formerly. An interesting example of the effects of these influences is furnished by division B, of the road from the records of which the figures in Tables I and II are taken. There were three other divisions on this road.

Most of the engines on division B were eight wheelers and quite light, when compared with the larger engines on the other divisions. During the years 1895 and 1896, when compared on the engine-mile basis, the average cost of engine service on this division was nine per cent less than the average for the system, including B. As events showed, this was largely due to the fact that the engines were comparatively light and handled relatively light trains. The use of the ton-mile basis for motive power statistics was begun with the year 1896 and showed the cost of engine service on division B was 13.6 per cent greater than the average for the system. This resulted in twice increasing the tonnage ratings on this division. As a result of these increases, for the first six months of 1897 the average cost of engine service on division B was found to be only 1.2 per cent higher than the average for the whole system, and this in spite of the fact that the average for the system had meanwhile decreased nine per cent, as determined by the ton-mile unit.

There will, in all probability, be no dissent to the conclusion that the result of the substitution of the ton for the car in rating locomotives, and the consequent use of the ton-mile basis for statistics, has been to increase operating efficiency and reduce the cost of transportation, and that it is a good illustration of the growing tendency to substitute scientific for unscientific methods in railway operation. The discussion would, however,

fall far short of completeness if it did not include another phase of the subject, at least suggest that there is still room for decided improvement and call attention to the fact that tonnage ratings, though a decided improvement over the car ratings, may easily be carried to extremes and result in increased, instead of decreased, transportation costs, and that there is still a wide field for scientific investigation in the matter of locomotive ratings and transportation statistics.

It is very generally assumed that the maximum tonnage a locomotive can handle at a speed of about ten miles an hour is the most economical. I venture to differ from this opinion and will first consider the matter as applying to the conditions which have prevailed throughout the past winter, during which time there has existed practically a freight blockade. Under these conditions the paramount issue, to borrow a political phrase, is to handle the business offered and keep it moving almost regardless of cost; in short, to handle the largest possible number of cars with the power and facilities available.

For the sake of argument and illustration Table III is presented. It applies to two divisions; the first one hundred miles and the second two hundred miles in length, and is based on the following assumptions: First, that it requires four hours to get an engine from its train to the roundhouse, clean its fires, give it necessary repairs, furnish the necessary supplies and have it on its train again; second, that a train of forty cars will allow an average speed of ten miles an hour; third, that a reduction of the train from 40 to 35.2 cars, or twelve per cent, will permit an increase in the average speed to fifteen miles an hour.

TABLE III.

	100-Mile Division.		200-Mile Division.	
Speed, miles per hour	10	15	10	15
Hours between terminals	10	6.67	20	13.32
Hours at terminal	4	4	4	4
Hours for one trip	14	10.67	24	17.32
Trips in thirty days	51.4	67.5	30	41.6
Cars hauled per trip	40	35.2	40	35.2
Cars hauled per month	2056	2376	1200	1464
Gain in cars handled per month		320		264
Gain in cars handled per month, per cent		16		22

These figures show an increase of from sixteen to twenty-two per cent in the number of cars an engine will handle per month due to a decrease of twelve per cent in the number of cars handled per train, and that the longer the division the greater the increase. Some may question the fact that this reduction in tonnage rating will allow the increased speed claimed, but I am confident those who have made the test will be least

inclined to disagree with the statement. When one considers that, though there will be a greater number of trains to meet and pass because of the fewer cars per train, the lighter trains will not only make better time between stations, but will also undoubtedly lose very much less time waiting at stations for other trains, because the heavier train will frequently wait rather than take chances of making an advanced meeting point for lack of a few minutes, it seems likely the lighter trains will make even better running time between terminals than shown in the tables.

This conclusion was amply confirmed by personal experience during a period covering a couple of months, during a series of locomotive tests in heavy freight service, when the time lost waiting at stations for other trains frequently reached forty-five per cent of the total time between terminals. This experience was had on a road which was single track for three-quarters of the distance over which the tests were made. If these conclusions are justified for a single track road, it would seem logical to assume there would be less room for doubt on a road having two or more main line tracks, when there would be fewer trains to meet and pass.

It seems evident from this discussion that, when business is such that the locomotives available are insufficient to handle it, freight blockades are imminent, and the tonnage ratings are such that speeds of ten miles an hour or less are the result, the number of cars handled per locomotive per month can be considerably increased by reducing the tonnage ratings slightly, thus allowing an increase in the speed and increasing the efficiency of the engines.

The following is quoted from a letter written by a well-known Superintendent of Motive Power, whose experience and opinion carry great weight: "I remember a case on the Blank railroad where, on a two per cent grade, an engine was loaded with forty tons more than the figured rating and was only able to ascend the hill at about four miles an hour. When the rating was reduced from 650 to 610 tons the speed was about doubled. It is a well-known fact that, in cases of freight blockade, it is considered better operation to reduce the load and so let the engines get over the road faster and relieve the congestion than to attempt to load them with the full tonnage. It also enables them to make meeting points to a very much better advantage, and, while I have no exact figures as to its effect on the cost of operation, yet know in a general way that it is decidedly advisable to take such steps under the conditions mentioned."

Of equal interest and weight is the following expression from another Superintendent of Motive Power: "While I know that the management has gone to the extreme in the matter of tonnage ratings and the movement of traffic has been curtailed by reason of it, there have been so many other elements that have entered into the question, such as limited terminal facilities, overcrowded condition of a single track road, bad fuel and frequent changes of enginemen, that it has been impossible to definitely determine what percentage of overtime and long hours on the road have been due to excessive tonnage or to the other causes mentioned.

"We do know, however, that in all cases where a congestion of business has occurred on any division a reduction in the tonnage of trains has resulted in an increase in the speed of movement of traffic and has invariably raised the blockade, and this without assigning any more power to that division. . . During the time the maximum tonnage was handled we were in daily receipt of engine failures, due principally to engines leaking, not steaming, etc., which the operating officers, as a rule, claimed as the cause of long hours on the road. The position I have always taken is that these failures were due to the long hours on the road and that the long hours were the cause and not the result of engine failures. The immediate improvement in the reduction of engine failures, with the reduction of tonnage, was certainly conclusive evidence of the correctness of this position."

This suggests the thought that, inasmuch as the number of cars handled per month can be increased by reducing the maximum tonnage ratings, it is possible this reduction of ratings may result in decreasing the cost per ton-mile, and an investigation shows that this will probably be the result, at least during the seasons of unusually heavy business. As already indicated, it is almost inevitable that trains which have the maximum tonnage will much more frequently remain on sidings, rather than take chances of making advanced meeting points, than would be the case if the tonnage were somewhat smaller, because the chances of the heavier trains breaking in two on pulling out of sidings, of their failing to make a meeting or passing point against a superior train because of bad weather conditions or dragging brakes, are much greater than their larger tonnage would indicate at first glance. We would, therefore, expect the wages paid for overtime and the cost of fuel wasted on side tracks and in taking and leaving sidings, and the cost of car and engine repairs to be more than proportionally greater for the heavier tonnage. Unfortunately it is nearly impossible to obtain accurate statistics to show whether this conclusion is warranted or not, but there are a few figures available which, while not directly applicable, may serve as guide posts.

The following figures give the percentages of overtime paid engineers and firemen, in relation to their total wages, during June, when there was no special rush of business and the engines available were ample to handle it easily, and during September, when the power was taxed to its utmost capacity.

	Division A.	Division B.
June — Overtime, per cent of total wages......	1.8	2.0
September — Overtime, per cent of total wages.	5.3	4.6

The above shows conclusively that the overtime paid increased from two to three times as much as the business done, as determined by the wages paid enginemen. It does not necessarily follow that all the increased percentage of overtime was due to maximum tonnage ratings, but there can be little room for doubt that, had the tonnage ratings been moderately

reduced, the increase in overtime would not have been so much heavier than the increase in business done, and it seems a fair inference that the cost of wages for train and engine crews, and to this extent the cost of transportation, was heavier per ton with the maximum ratings than though these had been reduced so as to allow a somewhat higher average speed.

The reasons which make it seem more than probable that a reduction of maximum tonnage ratings would decrease the cost of wages per ton-mile apply with equal force to the cost of fuel; not that the cost of fuel while running would be much, if any, greater per ton-mile with the maximum tonnage, but that the longer delays on side tracks, the longer hours for the train and engine crews and the damage done the fire while pulling out of side tracks with the heaviest trains would result in a greater cost of fuel per ton-mile. As to which cost, wages or fuel, would be increased the greater amount would depend on the cost of fuel and the conditions for which overtime is paid. I have some data which clearly indicates a saving in fuel by reducing somewhat the maximum tonnage ratings, but unfortunately the average speeds, average weight per car and other items are lacking, which make a conclusion drawn from these records but little better than an opinion.

In this connection an article in the *Railway Age* of January 23, 1903, by Mr. William Bennett, is of more than passing interest. The following is quoted from it, though I have rearranged the table so as to separate the cost of fuel and wages per ton of coal.

"Touching the economies in the transportation of freight, here are some interesting figures bearing upon the economical trainload and based on experiments made under similar conditions and showing the effect of change in tonnage:

MAXIMUM LOAD.

45 cars bituminous coal, gross		1,935 tons.
45 " " " net		1,215 "
Wages of train and enginemen, 22 hours at $1.35		$29.70
Coal consumed, 17 tons at $2.87		48.79
Cost of hauling, per ton of coal, wages	$2.45	
" " " " fuel	4.01	
Total,	$6.46	

THE SAME TRAIN REDUCED FIVE CARS.

40 loaded cars, bituminous coal, gross		1,720 tons.
40 " " " " net		1,080 "
Wages of train and enginemen, 17 hours at $1.35		$22.95
Coal consumed, 9 tons at $2.87		25.83
Cost of hauling, per ton of coal, wages	$2.13	
" " " " fuel	2.39	
Total,	$4.52	

"This result, practically unchanged, was obtained in a number of experiments."

Summarized, these figures show that a reduction of eleven per cent in the tonnage increased the average speed between terminals thirty per cent; decreased the cost of wages thirteen per cent, of fuel forty per cent, and the total cost of wages and fuel thirty per cent per ton of net load. If to this saving in wages and fuel is added the larger number of tons the engine handles per month, because it is on the road five hours less per trip with the reduced tonnage, a very respectable showing is made for the reduced tonnage. It is more than probable that the average saving under general service conditions will not be as much as shown above, but if it is only ten per cent or even five per cent, it represents a saving and increased efficiency which is worthy serious consideration and investigation.

In the issue of the *Railroad Gazette* for March 2, 1900, is a very interesting and valuable article giving the results of a series of elaborate tests made to determine the most economical rate of speed for freight trains on the Northern Pacific. These were found to vary from twelve to eighteen miles an hour, according to the class of engine and the varying conditions on the different divisions; the average being 15.4 miles an hour.

I believe the discussion and facts given warrant the conclusion that tonnage ratings which limit the average speed of freight trains to ten miles an hour, or less, result in a greater cost of transportation and decreased earning power for motive power than ratings which allow a somewhat higher speed. If this conclusion is accepted, it follows that such maximum tonnage ratings produce a higher cost of transportation than is necessary and that the subject is well worth extended, careful and scientific investigation.

SUMMARY.

The adoption of tonnage ratings for freight trains has reduced the cost of transportation by increasing the average trainload; by reducing the cases of doubling and overtime; by furnishing a basis of common interest for the operating and motive power departments to handle full trains, and by furnishing a fairer basis for judging operating and motive power efficiency.

It seems, however, evident that, as is usual when any new plan has proved beneficial, the pendulum has swung to the opposite extreme and the maximum tonnage ratings are, as a rule, greater than the most economical ratings. At least the evidence at hand warrants systematic and scientific investigation.

THE PRESIDENT: We will be pleased to have a discussion on this paper, as the subject is important and we hope the members will not lose time, as we have considerable business before us.

MR. D. VAN ALSTYNE: I would hardly regard with much favor the proposition to decrease expenses and increase the ton-

nage handled by decreasing the rating of the engines on the average railroad. It probably would result in some good on a water-level road, or on a road with a constant grade, but the average railroad is neither one nor the other, and the train load is governed by one or two ruling grades. The economy lies in getting the tonnage up to what the engine can drag over these grades, and on the balance of the road there is no difficulty. It is true that it is easier for a despatcher to handle trains if he knows he can count on the trains making their meeting points, by not having too large a tonnage; but, on the other hand, it is just as true that there are a great many side tracks that are badly located for getting in and out, and I am inclined to think you would lose about as much as you would gain, by reducing tonnage and increasing the number of trains. In addition to that, it has been my experience that any reduction in engine rating, which increases the number of times an engine has to go into the side track and roundhouse, is fatal to a good coal record. The amount of coal consumed in side tracks and at terminals very largely governs the coal record that an engine will make; and any proposition to improve the coal record on the ton-mile basis by reducing the tonnage and putting the engine more frequently into the side tracks and roundhouses will result in an increase rather than a decrease.

MR. MILLER: I agree with what Mr. Quereau said. As I understand the proposition, he does not propose to increase the number of trains or decrease the load so that the expenses would be increased. His proposition is to put the train load at such a point as will both give better service and decrease the expenses. Each division of any railroad will have to be considered separately in such a proposition, and if it were found that decreasing the train load would increase the expenses then it would be necessary to go back to the old system. If, however, there was an improvement and a lighter load would decrease the expenses, certainly the train should be lightened to that extent.

MR. WILLIAM MCINTOSH: I agree with Mr. Quereau's conclusions that there is no economy in loading locomotives beyond the economical point, and, in fact, I think in some cases there is considerable being lost in the way of overtime and delayed movement generally to the service in this way.

better understanding of the means of transforming power by means of the locomotive, and in accord with this suggestion the Executive Committee appointed this committee and gave the following instructions: To present for consideration subjects for investigation, to outline in a general way the manner in which the tests should be conducted and the methods to be pursued, and to give an estimate of the approximate cost of the investigations which are recommended.

At the first meeting of the committee it was thought that there might be one or two questions concerning locomotive performance which would stand out so preëminently as needing consideration, that by correspondence with the prominent men who are associated with locomotive work attention would be concentrated upon a few questions, and that then it would be a comparatively simple matter to carry out the further instructions to the committee and to outline the experiences and to give an estimate of the cost of them. It was found, however, that the only question suggested by a number of correspondents was the one relating to piston and slide valves, and, inasmuch as there is this year a committee considering this subject, it is considered best to await the results of the labors of that committee. It was found that upon the locality depends much the importance attached to some subjects; that a question which is considered of considerable importance in one section of the country is not of so much importance in another section, and any investigation which is undertaken at the expense of the Association should have as the principal object the securing of information which shall be of most value to the greatest number. It is understood by this committee that there are such questions for investigation as are of very general interest, but the committee thought that it was undesirable, under the present circumstances, to outline tests and would prefer that the Association should discuss the suggested subjects in convention, and therefore they present for discussion and for recommendation of their importance, the subjects which were submitted to this committee. This action of the committee, it is thought, will not inconvenience the Association and will not delay desirable experiments because it is understood that investigations now in progress, supplemental to the tests of exhaust pipes and stacks which are being conducted for the *American Engineer and Railroad Journal* by Professor Goss, will give to the Association for the next year ample scope for experimental work.

The committee desires to endorse the practice which is already inaugurated of proving by service conditions deductions made from the results obtained from laboratory tests.

In the appendix is given the list of subjects which were suggested to the committee. If two or three of them could be endorsed by the convention as being of prime importance, our recommendation would be that a committee be appointed for each subject so endorsed and that the duty of each such committee with reference to the respective subject be the same as prescribed for your present committee.

CONCLUSION.

Your committee find no difficulty in suggesting important subjects for investigation and append to the report a list for consideration. In view of the fact that the investigation of the subject of draft application is not completed it does not seem desirable to recommend the undertaking of additional work, at this time, and the report recommends a consideration of the subjects presented with a view of discussion and selection for action in the future when the present shall be completed.

Your committee has in mind the possibility that by the time the Association is ready to undertake additional tests, the relative importance of the subjects may change, which is an additional reason why it is not desirable for them to make a definite selection now.

BOILERS.

1. The best and most improved type of boiler for heavy passenger and freight locomotives, with a special view to eliminating stay bolts, radial or sling stays and braces, and with a sufficient area of heating surface to supply cylinders when engine is worked to its maximum capacity; fuel to be used, bituminous coal (run of the mine) and fuel oil. Also to determine the safe water level over the fire box when locomotive is worked to its full capacity at maximum steam pressure on a grade of from two to three per cent.

2. To what extent is steam furnished cylinders during the maximum demand for steam at full boiler pressure free from water; test to cover one or more trips of locomotive between terminals. This test to have particular bearing on height of water carried above crown sheet, length of cut-off and speed of engine to be carefully noted.

It is to be assumed that one test will be made on a division in bad-water district.

NOTE.—The specific object of this test is to determine to what extent the locomotive boiler, of modern design, has accomplished the object of providing a steam space of sufficient capacity to furnish dry steam under all conditions. In this connection, it is fully understood that moisture or entrained water in steam furnished cylinders is a direct heat, or fuel loss, also materially affecting power of engine and rapid wear of cylinder surface.

3. Determine the amount of heating surface required per horse-power for the various conditions of locomotive service.

4. Determine maximum horse-power which can be maintained continuously in simple and compound engines for a given heating and grate surface.

5. Relation between boiler pressure, initial cylinder pressure, the mean effective pressure, and speed of piston.

6. Coal tests to determine best proportion of grate surface for various grades of fuel, principally with a view to determining the best dimensions of wide fire box grates.

7. Determine proper depth of fire box under the tubes.

8. Determine proper tube spacing, considering the circulation, durability of tube sheet and steaming capacity.

9. Have there been experienced the anticipated or other difficulties with the longer boiler tubes, and have any been experienced which are unsurmountable?

10. Determine the most economical length of boiler tubes, in connection with area of tube.

11. Determine the causes of leaky flues and methods of overcoming.

12. Determine circulation in locomotive boilers of different types, including corrugated fire box boilers.

13. Determine the influence of scale on the evaporative efficiency.

14. Determine the best point to introduce feed-water.

15. The practicablity of heating feed-water.

16. Determine the economy and advisability of piping exhaust from the air pump into tank.

17. The use of superheated steam.

18. Applicability of water tube boilers to locomotives.

TRACTIVE FORCE, ADHESION, VALVES AND VALVE GEAR; CYLINDER CLEARANCE; BACK PRESSURE.

19. Test and calculation to determine variation in tractive power in starting and at different speeds and the effect upon slipping.

20. Determine whether modern conditions favor the advisability of changing the Master Mechanics' Association's coëfficient of adhesion for passenger, freight and switching locomotives.

21. Train resistance at high speeds.

22. Locomotive resistance at high speeds as influenced by cross section of the locomotive.

23. Valve dynamometer tests to determine the friction of piston and slide valves of modern locomotives.

24. Comparison of types of slide valves, with a view of perfecting the design of the piston valve.

25. Determine the proper clearance volume for simple engines and for two and four-cylinder compounds, high and low pressure cylinders, and to determine whether undue compression can best be reduced by increasing clearance volume or by cutting out the exhaust edges of the valve, and what are the limits in each case and the effect upon economy.

26. Determine the effect of steam-chest air valves and by-pass valve, and to determine whether it is advisable to use by-pass valves, and if so, for compound engines only, or in the large cylinders of simple engines.

27. Determine effect of the inertia of the reciprocating parts of the valve gear, especially when drifting at long travel and high speeds.

28. Indicator tests to show the relation of size of exhaust nozzle to back pressure at various speeds.

FUEL.

29. The possibility of preventing smoke.

30. Determine economical train speeds from the standpoint of fuel economy.

31. The fuel economy of compounding.

32. Determine what can be done with firing locomotives with pulverized fuel.

33. Determine better methods of using oil in locomotives.

34. Applicability of stokers to the locomotive.

35. Determine proper openings in ash-pan and their relation to grate and fuel area, in order to get free admission of air.

36. Determine the best relation of stack size to grate and heating surface, as there are reasons to believe that stacks that are of the right size for engines with small fire boxes are not large enough for fire boxes having large grates, even when the amount of heating surface is the same in each case.

MATERIALS FOR VARIOUS PARTS.

37. The best formula for iron used in locomotive cylinders, piston heads, and cylinder packing rings castings; also, the best form of piston heads and packing rings to be determined at the same time.

38. The best design and kind of metal to be used for driving axles, for the heavy modern type of passenger and freight locomotives.

39. The best design of driving-box bearing and manner of applying, also best known composition for driving-box bearings and crank-pin bearings.

40. Determine proper pressures for journals, engine truck, driving and tender, for various conditions and surface velocities.

41. The best form and material to be used in constructing connecting rods for modern locomotives, steel versus iron. In this the question of making repairs to rods to be considered.

F. M. WHITE,
A. W. GIBBS,
E. D. BRONNER,
Committee.

MR. BASFORD: I might add that the committee had in mind, while not expressed in the report, the fact that in connection with the discussions at our meetings subjects are continually coming up requiring scientific investigation. In view of the difficulty in selecting subjects from this list, and the fact that the Association is now busy on one important subject, it probably will be advisable to simply put these subjects on record as interesting and important topics for future consideration.

THE PRESIDENT: The subject is now open for discussion. If

there is no discussion and no objection, the report will be received and printed in the Proceedings. The next business is the report of the Committee on Revision of Standards and Resolutions, Mr. T. A. Lawes, chairman.

Mr. Lawes read the summary of the committee's recommendation. The full report is as follows:

REPORT OF COMMITTEE ON REVISION OF STANDARDS, RECOMMENDATIONS AND RESOLUTIONS.

To the President and Members of the American Railway Master Mechanics' Association:

Your committee begs leave to report as follows:

STANDARDS.

Standard Sizes of Nuts and Bolt Heads.

The committee recommends the adoption in full of the M. C. B. Standard on this subject just as it stands. The M. C. B. Standard is better covered and provides for the distinction between the rough and finished sizes of nuts and bolt heads.

Sheet Metal Gauge, Page 391.

The committee has no recommendations to make.

Distance Between Backs of Flanges, Page 391.

At the convention of 1884, the distance between backs of flanges for tender, locomotive trucks and driving wheels be not less than 4 feet, 5¼ inches nor more than 4 feet 5½ inches.

In the report of Committee on Flanged Tires, in 1900, they concluded it was desirable to set front and back tires on consolidated engines so the distance between backs of flanges will be 4 feet 5⅛ inches.

Therefore, the committee recommends the distance between backs of flanges be changed to read "to be not less than 4 feet 5⅛ inches nor more than 4 feet 5½ inches."

Limit Gauge for Round Iron, Page 391.

The committee has no changes to suggest.

Driving Wheel Centers and Size of Tires, Page 392.

Driving wheel centers seem to afford in a large majority of cases, sufficient diameters, but quite a number of locomotives have been built lately that use wheel centers not conforming to Master Mechanics' Standard.

The committee does not recommend any further addition to wheel center standards, believing them to be in the main satisfactory. We recommend that a committee be appointed to revise the shrinkage allowance to provide for the necessary difference between cast-iron and cast-steel centers, also to provide for the proper shrinkage allowances for the larger diameter of tires which are not now provided for, namely: 70, 74, 78, 82, 86 and 90 inches.

SECTION OF TIRE, Page 393.

In the section of tire there is a draftsman's error.

The Master Mechanics' Standard shows a cylindrical tread for a distance of one inch from the root of flange, and the M. C. B. Standard tread shows a conical tread coned 1/8 inch in diameter (1-16 of an inch on a side) in the first 2 3/8 inches from the root of the flange. The difference is slight, but it causes manufacturers of tires some trouble in rolling tires to meet both specifications. As there appears no good reason for the difference in the two standard sections, the committee recommends that the drawing of section of tire conform to M. C. B. section.

BOILER AND FIRE BOX STEEL SPECIFICATIONS.

The committee recommends that the boiler and fire box steel specifications be revised, and that a committee be appointed for that purpose.

EFFICIENCY TESTS OF LOCOMOTIVES, Pages 396-414.

The committee believes these need no revision.

SPECIFICATIONS AND TESTS FOR IRON BOILER TUBES, Pages 414-416.

The committee recommends that these be revised and provide for steel tubes.

DECIMAL GAUGE, Pages 416-417.

The committee has no recommendations to make.

BRIGGS' STANDARD WROUGHT IRON PIPE THREADS, Pages 417-418.

We find that many manufacturers do not adhere to these standards, but the remedy lies with the consumer to specify Briggs' Standard for wrought iron or steel pipe threads.

The committee has no further recommendations to make regarding this standard.

SQUARE BOLT HEADS.

The committee has no recommendations to make.

RECOMMENDATIONS.

MILEAGE ALLOWABLE.

(1) Switching engines; (2) Local freight engines; (3) To and from roundhouse; (4) Switching service on through freight and passenger engines — Page 419.

The committee recommends these mileages should be omitted. The Committee on Ton-mileage is considering this subject, and no doubt will report allowances which will be more satisfactory.

BETTERMENT OF ENGINE EQUIPMENT, Page 419.

The committee recommends this subject be omitted, as in our opinion it is an auditing matter.

AXLES — $3\frac{3}{4}$ BY 7 INCH JOURNALS AND $4\frac{1}{4}$ BY 8 INCH JOURNALS, Page 419.

The committee recommends the addition of M. C. B. Standard Axles with 5 by 9 inch and $5\frac{1}{2}$ by 10 inch journals to above recommendations, and adopted as standards of the Association.

JOURNAL BOX AND CONTAINED PARTS, CARS AND LOCOMOTIVE TENDERS.

The committee recommends that the M. C. B. journal boxes and contained parts for all M. C. B. Standard Axles should be adopted as standards of the Association.

SPECIFICATIONS AND TESTS FOR CAST-IRON WHEELS.

We recommend that a committee be appointed to revise these specifications and bring them up to date, and applicable to present requirements for dimensions for cast-iron tender, and engine-truck wheels.

AIR-BRAKE AND SIGNAL INSTRUCTIONS.

We recommend that as these rules are not up to date and do not cover many points in present practice, a committee be appointed to confer with a similar committee from the M. C. B. Association, and from the Air-brake Association, and present a revised code of rules at the next convention.

CODE OF APPRENTICESHIP RULES.

The committee has no changes to recommend.

RESOLUTIONS.

The committee recommends the omission of the following resolutions from Annual Proceedings:

Safety chains on all trucks.

Loose wheels and compound axles.

Steel for fire boxes.

The committee approves of the retention in the Annual Proceedings of the following resolutions:

Testimonial letters.

Beading flues.

Steps on pilots of engines.

Radial stay boilers.

Train load and basis for locomotive performance.

Instructions regarding use and repairs of air brakes.

Fusible plugs.

Ton-mile basis for motive power statistics.

Bars in exhaust nozzle.

Comparison in motive power statistics.

Ton-mileage of locomotives.

Side-rods on new engines.

Resolutions regarding ton-mile statistics.

Water glasses.

Under resolution covering brick arches the convention of 1888 passed the following resolution:

"That it is the sense of this convention that a brick arch applied to the fire box of the locomotive is a desirable addition for all service, and a positive advantage."

There are many types of engines in which a brick arch is not possible as well as not desirable. The committee recommends that this resolution be omitted from the Annual Proceedings.

THE COMMITTEE'S RECOMMENDATIONS ARE SUMMARIZED AS FOLLOWS:

1. Adoption of M. C. B. Standards for bolt heads and nuts.
2. Distance between backs of flanges for driving, engine truck and tender wheels to be not less than 4 feet 5⅛ inches nor more than 4 feet 5½ inches.
3. That a committee be appointed to revise shrinkage allowances to provide for the necessary difference between cast-iron and cast-steel centers, and to provide for the larger diameters of tires; namely, 70, 74, 78, 82, 86 and 90 inches.
4. Section of tire; Master Mechanics' Standard to conform to M. C. B. Standard.
5. A committee be appointed to revise boiler and fire box steel specifications.
6. A committee be appointed to revise specifications and tests for boiler tubes, and provide for steel tubes as well as iron tubes.
7. Recommendations regarding mileage allowable for engines be omitted from Proceedings.
8. Regarding betterment of engine equipment to be omitted from Proceedings.
9. The adoption of M. C. B. standard axles as standards of the Association.
10. The adoption of M. C. B. journal boxes and contained parts for all standard axles, as standards of the Association.
11. A committee be appointed to revise specifications and tests for cast-iron wheels for engine trucks and tenders.
12. A committee be appointed to present a revised code at the next convention of air-brake and signal instructions after conferring with a

similar committee from the M. C. B. Association and the Air-brake Association.

13. Omission from Proceedings:
A. Safety chain on all trucks.
B. Loose wheels and compound axles.
C. Steel for fire boxes.
D. Brick arches.

T. A. LAWES,
WM. MCINTOSH,
A. M. WAITT,
Committee.

DANVILLE, ILLINOIS,
May 29, 1903.

MR. ANGUS SINCLAIR: I move that the changes recommended by the committee be adopted.

Motion seconded and carried.

THE PRESIDENT: The next report in order is that on "The Progress of the Year."

MR. H. D. GORDON: In the absence of the chairman of the committee, Mr. A. Kearney, I will simply say that the committee has not attempted to go into the subject thoroughly. It is a very large one and, without going into statistics of any kind, the report simply touches in a general way on the most important points in which progress seems to have been made. A number of these are embodied in reports to the Association at this convention and seem to have been very ably handled. In reference to the paragraph on page 5, which reads: "None the less interesting and important have been the valuable and painstaking researches conducted under the direction of Prof. W. F. M. Goss for the purpose of defining and proving the laws controlling the most economical and efficient draft appliance for locomotives, and as this feature is so vital in their design, the mechanical world is certainly very much indebted to Professor Goss for this liberal and valuable data." I wish to say that this has reference to the tests being conducted for the *American Engineer and Railroad Journal* by Professor Goss. The great value of these tests has been recognized by this Association and a committee appointed to assist Professor Goss and make a report to the Association this year. I simply mention this to prevent misunderstanding.

The report is as follows:

REPORT OF COMMITTEE ON THE PROGRESS OF THE YEAR.

To the Members of American Railway Master Mechanics' Association.

Looking back over a short period of one year for the progress made in locomotive engineering—the development of radical designs and strides in general construction—we find, as a matter of fact, very few essentially novel departures have found their way into prominence, but at the same time it should be especially gratifying to the designers to note the widely growing sentiment and interest with which certain comparatively recently established lines are being developed, and developed too, to the satisfaction and gratification of the railroad managers; and this has been made so for the reason that the designs have been trimmed, so to speak, and made more reliable by strengthening certain details, not to lose sight of the capacity to handle increased business with fair economy.

Notably is this true, it may be said, of the almost universal adoption in this country of the so-called wide fire-box type of boiler, having a grate area of between fifty and sixty square feet, with a sloping back head, being a medium between the former narrow box, with its grate area of thirty to forty square feet, and the Wooten type of fire box, having a grate area in the neighborhood of seventy square feet. This widening of the fire box has been productive of two quite apparent advantages in the design of boilers, namely, it permits of a wider mud ring than was formerly possible with the narrow box, resulting in a better water circulation over and about the flat surfaces, and also admits of the use of longer stay bolts. The natural result of the latter change being in the direction of increasing the life of the stay bolts by reason of greater flexibility. There is another advantage to which attention may be directed, briefly, and that is the increased heating surface, resulting from the change in the back end of boiler, and this is obtained in that portion of the boiler where it is most efficient per square foot.

The sloping head, which has also been a feature of a large number of locomotives built with this type of fire box, means not only a better distribution of the weight in the boiler, but also provides for possibly more efficient heating surface in the door sheet, due to the slope being such that the hot gases and products of combustion impinge upon and tend to follow its surface more readily than with the straight back sheet.

The proper proportioning of heating surface has also received a great deal of attention and thought by all locomotive designers, and probably more so during the past year, owing to the adaptability of the longer flue to the six-wheel connected type of passenger engine, having a pair of trailer wheels under the fire box. There has been an apparent endeavor to obtain the same result through another course; namely, to increase the number of flues, decreasing correspondingly their distance from center to center. The growing belief seems to be that there is a limit to the efficiency of the heating surface secured in the latter manner, and that possibly the same results may be gained by increasing the distance from center to center of flues, thus securing a more rapid and better water

circulation. Following out this line of thought, it would seem that such designs would be especially well adapted for districts where impure and scale-forming waters prevail. Various theories and formulæ have been advanced for the purpose of expounding the proper proportions for heating surfaces. None, however, seem to have evolved the exact, or a hard and fast ratio to meet the widely differing conditions of service, except in an approximate way. The best researches and, therefore, the most authoritative work seems to have been carried along the lines and upon the assumption that reasonably safe proportions can be obtained by using the predetermined figure of horse-power required, together with the fixed economic evaporation per unit of heating surface; the former being obtained in the usual way from a maximum tonnage to be hauled at a maximum or average speed at an established resistance per ton.

Mention might be made of an instance of a substantially similar design of locomotives, built by two different roads, both weighing practically the same, with cylinder volumes almost identical. The first, it seems, has a heating surface of some 3,500 square feet, 396 tubes, sixteen feet long; while the second has but 2,600 square feet of heating surface, with 315 tubes, fifteen feet long. It is reasonable to suppose that the designers of the second locomotive based their calculations upon obtaining an equal capacity boiler, and probably even more efficient heating surface per square foot, resting upon the assumption of a more rapid circulation of water, which is permitted almost entirely by the increase in the distance from center to center of flues, sacrificing the flue capacity numerically.

Some small amount of literature has been devoted to the construction of what is said to be the largest passenger locomotive in the world, which machine is supposed to have a total weight on drivers of 144,000 pounds, cylinders 22 by 28 inches with a heating surface of 4,064 square feet. The tubes in this locomotive are reported as being twenty feet long. It is a very much mooted question whether the efficiency of the heating surface of tubes of this length is enough to suffice the increased length, or, in other words, does the addition of four feet to an already long flue, say, sixteen feet, permit of the use of an unchanged formula. These are intensely interesting and none the less important proportions and laws that are receiving the attention of the prominent and best designers, and with the knowledge secured through experiments and literature devoted to the question, it is gratifying to know that the subject is, at least, one which is gradually being mastered.

While upon this subject of boilers it might be said further that the question of water purification is also receiving renewed attention, and we read constantly of sales of apparatus for this purpose, and have no doubt this manifestation of interest on the part of the Motive Power Departments is the result of the very thorough and interesting investigations conducted under the auspices of this Association several years ago with special reference to the cost of renewal of fire boxes and stay bolts,

considered in connection with their increased longevity, m de possible by the use of purified waters.

Speaking of large locomotives: There seems to be an apparent rivalry—at least that possibly might be the best name for it—among the different roads to reach the limit in weight and capacity, exemplified in the construction of a locomotive weighing in the neighborhood of 267,000 pounds and having 5,390 square feet of heating surface. And this, again, in the contemplated construction of one weighing possibly 300,000 pounds.

Right here attention might be called to the fact that, to the best of our knowledge, there have never been any statistics compiled, or at least published, in r gard to comparative cost per ton-mile for maintaining these heavy locomotives, weighing in the neighborhood of 200,000 pounds and over on drivers with those of lighter construction. Some such statistics as these would unquestionably be interesting at this time in view of the apparent tendency leaning so strongly towards the building of large locomotives.

A feature, which has made possible the larger locomotive of to-day, is the prodigious strides in the casting of steel parts. The art seems to have developed so rapidly that it can hardly be passed over without mentioning briefly the more general use of parts made of this material. For instance, cast steel frames which in themselves form a large percentage of the weight of locomotives. There seems to be no doubt as to the advantage of frames made of this material; although it is but recently that the question of welding has been taken care of satisfactorily, and to-day it is probably no more of an art or a difficulty to weld a frame of this material than one of wrought iron.

Of the number of locomotives built from May, 1902, to May, 1903, 47.2 per cent had cast steel frames, and it is quite common to find locomotives designed having cast steel parts to the amount of 30,000 pounds.

With the advent of the larger locomotives the problem confronts us as to best type of valve to use in connection with the very heavy motion gear. Much thought is being given this subject, and it remains to be seen what will be the result of the adaptation of the piston valves to some of the locomotives of "simple build." It is not the wish to burden the report with figures, but it might be interesting to note, from information furnished through the kindness of a number of the large locomotive builders of this country, that about 42 per cent of the locomotives built between May, 1902, and the corresponding period of this year, have piston valves.

The proper design of the valve is also an open question, but the tendency seems to be in favor of the hollow piston type. Of the piston valves applied during this period 69.5 per cent were of the hollow, while but 30.5 per cent were of the solid type. When we consider that about 18 per cent of the piston valve type of locomotives were compounds it is to be seen the advances in this direction have been rather conservative.

Interest in the tandem type of compound locomotives seems to have

been revived. On one road in particular, on which there have been about fifty of this type in service, it is said they have been very satisfactory. There are several roads, however, contemplating the abandonment of the compound locomotives for certain divisions and service. While there is probably no doubt but that the compound locomotives can be adopted under some certain conditions, yet their economical use seems to be dependent, and very reasonably so, upon the service and physical characteristics of the road.

As a matter of information it might be stated that of the total number of locomotives built in the period before referred to there were but 18 per cent constructed on the compound principle.

There have been numerous attempts from time to time to get away from the present method of forging axles, and to avoid the dangers of the so-called piping. An article recently appearing in several of the technical magazines describes a new process, which is a very wide departure from the present practice. In brief, it seems the process involves the forcing of a ram by hydraulic pressure into the end of the hot billet, forming the journal, wheel fit and part of the axle proper, by means of dies; and leaving hollow the portion so formed. Axles made under this process are said to have withstood very severe tests under the drop machine.

Nothing of note has been done with the question of the use of nickel steels for driving axles, but no doubt the subject is still in the minds of many, and they are quietly experimenting and investigating its relative merits. There has, however, been discovered an entirely new field for nickel; namely, in the manufacture of bearing metals. The peculiar properties resulting from the introduction of a small amount of this material in the alloys of copper and lead, seems to be that it prevents the segregation of the latter antifriction metal, allowing nearly double the amount to be introduced than was heretofore practicable.

The stay-bolt type of boiler seems to be still held in favor and this gives the manufacturers of stay-bolt irons the opportunity to still further pursue their investigations and experiments in an endeavor to obtain, possibly, a better iron for the purpose.

Progress is being made, and much thought given to improving the method of testing stay-bolt iron, with a view of making the specifications conform more nearly to service conditions.

None the less interesting and important have been the valuable and painstaking researches conducted under the direction of Prof. W. F. M. Goss for the purpose of defining and proving the laws controlling the most economical and efficient draught appliance for locomotives, and as this feature is so vital in their design the mechanical world is certainly very much indebted to Prof. Goss for this liberal and valuable data.

Numerous have been the experiments in an endeavor to render available the efficient properties of superheated steam, and the results seem to have been particularly successful in Europe. Recent papers by foreign writers go to prove that the advantages gained in their economical

performance more than justify the maintenance. Little, however, has been done on this continent, except in an experimental way on one of the Canadian Lines.

Reviewing the designs of some of the powerful locomotives, both for passenger and freight service, it is of interest to note the growing capacity of tenders and particularly the adherence to the comparatively new feature of the gradual elimination of the water legs, extending the cistern under the coal space.

The direct result of building large locomotives for the past two or three years has been the general recognition by the managements of the roads in this country of the necessity for increasing shop facilities. During the past year several new and very creditable shop installations have been completed and are now in operation. These may be regarded as models of equipment and liberal use has been made of the numerous improvements in machine construction and shop operation, having in view the reduction in cost of operation and output. Old shops have been modernized, built up-to-date, and, as stated before, the activity along these lines has been general. These improved facilities have been to a great extent made possible by the general prosperity and increase in the earnings of the railroads, and it is a wise management that realizes the importance of providing ample means for the maintenance of such a vital feature as the motive power and rolling stock of their road. It is a credit to the mechanical departments that have carried on the work of repairs with inadequate facilities, and they are to be congratulated upon the readiness with which they have evolved the modern up-to-date shop, a shop which can take its place freely in the front ranks of progress.

Perhaps the most prominent feature of all in the design of new shops has been the steps made toward concentrating in one, or continuous buildings, a number of the more important departments, and this, not with a view to a decrease in cost of construction especially, or of economizing space available, but primarily to decrease the time interval for handling material and incidentally the ultimate cost of production.

A large factor in the usefulness of this construction is the uniform adaptation of electric crane service to the handling of materials, brought about by the modern method of the electric driving of machine tools, doing away with shafting and its accompanying evils. There is no doubt but that this general policy of concentration not only results in large economy in labor, but permits of a better supervision, and as concentration of energy in the right direction accomplishes the best results, we believe that this policy marks a distinct progress in the mechanical branch of railroad engineering. There still seems to be much diversity of opinion among motive power people as to the best method of track arrangement in erecting shops, and it is a subject upon which much can be advanced in favor of either longitudinal or transfer tracks. There is one thing, however, that can be said, and that is, that the transfer table in locomotive shops is rapidly becoming a thing of the past in this country. The space is too valuable and the electric crane is an adjunct too promi-

nent in the eyes of those looking for economy in the handling of material to any longer countenance the inconveniences attendant upon the transfer pit. In car shops, however, the transfer table still seems to have its field, and necessarily so when we stop to think of the difficulty and injury that might accompany the handling of cars by cranes, especially long passenger equipment; although such a method might be entirely practicable. There does not seem to have been much change in the general construction of car shop buildings in themselves, outside of the fact that they have received their share of attention along with the locomotive shops in regard to improved heating, lighting, ventilation and electric driving of the shop tools.

There have probably been no shops in which such rapid strides have been made in the use of electricity as those of railroads, and practically every new shop built has been liberally equipped with these valuable appurtenances, and also many of the old shops have been modernized in this respect by the introduction of new power plants, tending toward economies in cost of output.

The introduction of high-grade tool steel, calling for a wider range of speed and more power, has brought about complications in the practice of motor-driving, and much has been done toward their solution. The builders of machine tools and electric apparatus have given the subject careful study and have brought about many improvements. The railroad clubs and technical societies have had many valuable papers presented, which have been ably discussed, and little of note has been allowed to go unrecorded, so that there is to-day probably a better and more general knowledge of the subject among railroad men than ever before. The multi-voltage system of electric drive has received its share of attention and investigation in an endeavor to increase the output of machine tools, and the progress along these lines by the electrical, as well as mechanical people, has been very rapid. The motive power people of the railroads have, however, been very cautious about adopting the system in their shops, for where the number of parts are so many and varied, as they are necessarily in railroad shops, it is a matter to be seriously considered, whether, by the adoption of this expensive method of driving, the amount saved will warrant the investment. One large electrical company has recently announced that it has succeeded in producing a motor having provision for speed variation by means of a variable resistance in the field circuit. This method is said to be economical and permits of a wide range of speed; we, however, question the economy of field resistance.

The introduction of high-grade tool steel has also made necessary the redesigning of a large number of the machine tools on the market. The various parts have been made heavier and the machines increased in strength and power of drive, and the economy resulting from the increased cutting speed, together with the feeds and cuts, have so increased the amount of material removed per minute as to more than offset any increase in the cost of tools. We see from time to time in technical

papers, and the subject is one of general interest, as to how many pairs of tires can be turned off of a certain machine in a day, or something in regard to the number of feet per minute a certain planer will cut and the amount of material removed in this time, etc.; in fact, it has grown almost into a race between the machine tool builders and the makers of tool steel.

For motor driven planers and other reciprocating machine tools a notable improvement is the application of the heavy fly-wheel to the motor shaft. The energy of rotation stored up in the fly-wheel during the cutting or return stroke assists in supplying the extra demand for power at the moment of reversal and by this means the overloading of the motor is reduced to a point well within the safe limit.

The finishing of parts by grinding, and especially wearing parts, has received much attention. It is only during the last few years that builders have taken up the subject of a proper design for these machines for railroad work, and machines are now made which will finish such parts as piston rods, crank pins, etc., better and cheaper than they can be done in the old way. With the disk type grinders many small forgings and other parts are now accurately and cheaply finished complete without machine work.

In general it might be said, in the way of increasing and improving shop facilities, enlarging the output, decreasing cost of production and the time required for repairs, quite as much progress has been made during the past year as in any one in the history of this Association; however, many interesting and at the same time perplexing problems remain to be solved. The large addition of heavy motive power constructed and set in motion during the past two years has already begun to "clamor" for its return on the repair tracks, having performed a fair proportion of useful service. It, therefore, behooves those at the wheel to carry forward to perfection the improvements already begun, as well as those under contemplation, while the opportunities are favorable.

Too much can not be said and in the highest terms of praise for the excellent work accomplished within the short period of an additional year in the life of this organization—a year now about to pass into history. Indeed, it will ever stand as a credit to the skillful and enthusiastic mechanical engineers and to the motive power departments of this country and can always be looked back upon with pride and satisfaction by the members of this Association.

ALEX. KEARNEY, Chairman,
H. D. GORDON,
S. F. PRINCE, JR.,
E. M. HERR,
Committee.

PITTSBURGH, PA., June 13, 1903.

THE PRESIDENT: The report is now before you.

MR. SELEY: I think that this is a very good presentation of the subject in general, and one that has fully warranted the idea of having a report on the progress made during the year. There is one little point I would call attention to, that the committee seems to be doubtful about. It is in regard to details of the electrical drive for shops, and the last sentence of the first paragraph on page 7 questions the economy of variable speed control. I think that statement in the report should be taken in connection with a careful study of the discussion which we had in the meeting yesterday.

On motion, the discussion was closed.

THE PRESIDENT: We will now take up the report on " Piston Valves," Mr. F. F. Gaines, chairman. As the chairman is absent, I would ask Mr. Clark to present the report.

The report is as follows:

REPORT OF COMMITTEE ON PISTON VALVES.

To the President and Members of the American Railway Master Mechanics' Association:

Your committee on the above subject sent out a circular of inquiry several months ago, and in reply have received considerable information and data. This for easier reference has been tabulated, the questions and replies being shown together on one sheet. In addition to the data received through the circular of inquiry it was intended to make tests between the new type of American balance slide valve and piston valve and submit report to the convention in connection with the report on piston valves, but circumstances have been such that this intention has not been carried out.

From the replies received it would seem that the type of valves more generally favored is either the hollow internal admission or hollow external admission, and while there is a fair proportion of solid internal admission valves there are very few solid external admission valves in use unless we consider the piston valve used on the Vauclain compound as being of this type. In classifying replies it has been considered that this valve was of the hollow external admission type, and was classed by all answering the circular as such. While hollow as regards construction, it is not so in the sense that steam may circulate from end to end, and that it is unbalanced as regards the area of valve stem when not equipped with extension through front head. As to which type is believed to be the most economical very few expressions of opinion have been given, the experience generally having been confined to one type of valve. There are, however, some

exceptions to this, the Boston & Maine road stating that for economy, as regards steam distribution, the hollow internal admission valve or the hollow external admission valve is preferable, as the steam passages are freest with these types, and for steam consumption the inside admission valve appears best, although no reason for the choice between the solid and hollow valves in this respect is seen. The first cost depends largely on the kind of packing rings employed, the outside admission valve costing somewhat more on this particular road on account of having to make valves, valve cases and packing rings of different sizes at the front and back ends of valve, due to equalizing the two ends of the valve stem. For maintenance they prefer the inside admission hollow valve because but one size of case is required, one size of packing ring to be kept in stock, and the metallic valve stem packing wears much longer. Also the valve is more easily removed and there seems to be less wear on the entire valve gear on inside admission valves.

The D. & H. Co. state: "In the spring of 1902, Messrs. Campbell and DuBois, seniors of Cornell University, made a comparative test in freight service of Class E-2 and E-3 engines. The engines were laden proportionately to tractive power. Deductions gathered from this test show a saving on the piston valve engine of 1.8 per cent due to valve. The piston valves were new, and the slide valves were recently shopped." While not so stated, this economy is apparently due to steam distribution, and as the percentage of gain is so small it is questionable if, after the elimination of errors of observation, there would remain any advantage. Several other roads express preferences, but without giving reasons so fully.

As regards the ratio of diameter of cylinder to cylinder of valve both in simple and compound engines there seems to be a large variation between the maximum practice and the minimum practice. In simple engines the ratio varies from 1.66 to 2.1. For the Vauclain compound system the high pressure varies from 1 to 1.38, and for the low pressure cylinder from 1.67 to 2.30. The variation in the other types of compounds is not so marked, due to fewer replies being received covering these types. It is the opinion of the committee that the lower ratios indicate the better practice and that the higher ratios should only be used on freight and switching engines.

Under the head of "Provision for Relief," the methods of obtaining relief from water and extra pressure is generally provided for by relief valves in cylinder heads. In some few cases there are, in addition, by-pass valves. relief valves in steam chests and on the compound engines, relief valves in low pressure ports, and on the end of a hollow valve stem. There is one exception to the above, the Southern Pacific furnishing a blue-print of a circulating pipe which will be found in Section IV of Appendix. The piston valve with hollow valve stem is illustrated in Appendix, Section I, Fig. 12. As regards the value of the various types of relief valves from water it is not thought that the valve in cylinder head fulfills its function in the manner that it is expected to. It has been the experience of one

road that these valves, after being in service for a short time, corrode, or through other causes fail to lift at the pressure at which they are set, and that they are of but little value as relief from water in cylinders. As to relief when drifting, very few of the by-pass valves or relief valves are thoroughly successful where the speed is high. It is possible that the circulating pipe previously referred to will do this to a greater extent than the other devices. Referring to the reply of the Southern Pacific Company, and quoting: "The circulating pipe sent herewith shows an arrangement that not only takes care of compression and surplus moisture, but, as will be seen by reference to the print, will also take care of temperature of cylinders when drifting. It takes care of the partial vacuum that is responsible for incandescent hot gases of smoke box entering cylinders through the exhaust nozzle. The piston valves in constant use for the past two years with this circulating device are in perfect order to-day, with little if any indication of wear. The cost of caring for the piston valves during this time has been nothing more than that of bushing the front end horn or guide when engines were shopped." The indicator cards showing operation of piston valve engine with and without this device will be found in Appendix, Section IV.

No affirmative replies were received to question No. 7, as to use of piston valves with collapsible packing rings, although it is known that such valves are in use on two roads, and that on both of these roads their service has been very satisfactory. A cut of such a valve is shown in Fig. 27, Section I, in the Appendix. The theory of this type of valve is that steam pressure being admitted through cavities under the packing rings, sets them out against the valve cage, but that when they are so set out, due to the different angles of the different rings composing the packing, they lock in this position and the valve practically becomes a plug valve. It will be generally conceded that the plug valve has some advantages over the other types, and that its great disadvantage is due to the wear of valve and bushing so as to gradually permit steam to pass between. It would seem, however, that this type of valve, being adjustable, would overcome this objection.

Various types of packing rings are in use, as well as rings of the same style varying greatly in their dimensions. The rectangular cast-iron snap ring, together with the cast-iron "L" ring, appears to be used in the majority of cases, while for the rectangular rings about 3/8 by 1/2 inch and for "L" rings 5/8 by 1/2 inch seem to be the prevailing sizes. In some few of the valves provided with followers heavier rings are used, and it is questionable if the prevailing practice is not too light rather than too heavy. As regards the various advantages of the rectangular and "L" shaped rings, it would seem that the rectangular rings generally have the advantage of strength, longer life, cheaper cost and cheaper maintenance, while to offset this, the "L" ring, especially on high-speed engines, gives a very much better port opening with less wire drawing off steam. The "L" ring naturally has a greater unbalanced surface than the rectangular

ring, and it is the experience of one road that it wears both itself and the chamber very much more rapidly than the rectangular ring. Your committee believes that in most designs the extension part of the "L" ring projects too far. As to the efficiency or economy of various types of rings. only one road has any data, the Chicago, Milwaukee & St. Paul furnishing a print of a special type of valve ring, which is shown in Fig. 20, Section I of the Appendix, and in connection with same furnishing a log of test of two valves, one having the test packing rings on one side and the other having ordinary packing rings on the other side. From the indicator cards it would seem that the steam distribution appears as good on one side as on the other, while they report that this bushing and ring have been in service on the right side of the engine for one year, the left-hand side being equipped with the regular bushing and rings. An examination made about a month ago shows that the valve having diagonal bridges and the broad ring was in perfect condition and had all the appearances that would indicate another year's service without repairs, while the opposite side, having the regular type of rings and bushings, had to have chamber rebored and new rings applied; the service thus far obtained from the bushing with the diagonal bridges and the broad ring packing seems to be very favorable. The general practice as regards the number of rings per end seems to be two rings, although there are several exceptions where three rings are used.

Relative to exhaust effect, the Chicago, Burlington & Quincy states as follows: "We have made experiments on valve friction of internal admission piston valves of both hollow and solid types. With the solid valve, cards taken show that at slow speed there is an excessive push forward on the valve when exhaust first opens. The average pull on the solid type of piston valve in comparison with the balanced and unbalanced slide valve is shown in enclosed test. (See Section V of Appendix.) With the hollow type of piston valve we get more uniform pull than with the solid type. However, with the end of the valve travel there is a sudden increase of pull which corresponds to the point of exhaust opening. The enclosed blue-print (See Section V of Appendix) gives the average pull in pounds of the hollow type of piston valve in comparison with the solid type."

A member of the committee also furnishes a copy of a paper read before the Richmond Railroad Club, in September, 1902, which bears so closely on this subject that it is given in full. (See Section VI of Appendix.)

The Boston & Maine states as follows: "We have made no test on piston valves for friction. We observed that when our first consolidation engines arrived, they soon began to sound badly out of square, the indicator diagram showing that the valves were not cutting off equally, yet no discrepancies could be found in the valve setting or motion work. The defect was attributed to the removal of pressure from back end of the valve by the valve stem, the greater pressure on the front end keeping the slack all taken up in one direction and allowing valve to keep as far back as possible.

This condition existed for speeds up to thirty miles per hour, above which, apparently, the inertia of the parts overcame the unbalanced force. The inequalities of the exhaust sound increased with increased slack in the motion work. The trouble was overcome by enlarging the back head of the valve by an area equal to area of the valve stem." Your attention is called to the other method of eliminating this difficulty by the use of an extended valve stem, several styles of which are shown in the different types of piston valves illustrated.

No experiments seem to have been made with a view to determining the steam lost due to worn rings, and judging from remarks made at the topical discussion on this subject at last year's meeting, it would seem that there is a wide variation of opinion as to the amount of this loss. One road states that while having made no accurate tests to determine the steam loss due to wear of packing rings, two of the Master Mechanics who had made shop tests on this point, are of the opinion that the rings can easily represent a loss of fifteen per cent over steam consumption with rings in first-class condition. It undoubtedly varies, due to several conditions — the type of ring, the size of ring, the type of valve and the length of period between reboring of valve chamber casings and application of new packing rings. One road states that where piston valves are used on engines, when on account of heavy grades there is a long drift, the frequent reboring of valve casings is economical in the long run as preventing broken packing rings and blowing.

Only two roads replying to the circular acknowledge having had any experience with the new type of American balance slide valve. One of these states that two engines are equipped with most excellent results. The other has had four engines equipped for about a year's time, and, with the exception of some minor difficulties in the start which were later overcome, the results have been very good. The valve, as will be noted (see Figs. 23, 24 and 25, Section I of Appendix), has both double admission and double exhaust features, and while no indicator cards have ever been taken to show how much has been gained by this feature, there can be no question but that it is an appreciable factor. Your attention is also called to the fact that with this type of valve, all balancing parts are stationary and not subject to wear, and that in two different ways a very short steam port may be obtained. One of these will be found illustrated in connection with the valve mentioned in the Appendix showing cylinders upon which it is used, and how, by making wide shallow exhaust cavity in cylinder, a short steam port was obtained. The other method by which this can be accomplished is to use inside admission, as there is nothing in the way of balancing this valve equally as well for inside as for outside admission, although it is believed the latter has not yet been tried. Notwithstanding the large size of this valve as illustrated, in connection with 210 pounds of steam, the engine can be handled with a full throttle with ease, showing that valve is perfectly balanced. It also has the advantage of providing for relief from over pressure in the cylinders by lifting in the

same manner as the ordinary slide valve, and on account of the double exhaust feature there must be considerable decrease in back pressure, which is evidenced to a certain extent by the very short, sharp exhaust.

The replies as to the chief advantages of piston valve seem to be fairly uniform and consist, in the main, of better balancing, which includes ease of handling and decrease in wear and tear of motion work. In addition, some replies give less cylinder clearance, better steam distribution, less cost for maintenance, shorter steam passages, decreased back pressure, better distribution, larger port openings; and on the four-cylinder compound the fact that the piston valve really takes the place of the two valves, in that it distributes the steam to both high and low pressure cylinder, greatly simplifies the motion work and the number of parts. It is questionable if all the advantages claimed are real and tangible, as it seems that some of these attributes can be obtained equally as well or better with other types of valve. It would seem that the question of lubrication is not a settled one. The reply of one road states that where engines with piston valves have to drift for long distances the question of properly lubricating the piston valve becomes a very serious problem, and it is hoped that a discussion of this paper will bring out some more definite information on these points. It would seem that the reason for the growing favor in which the piston valve is held is due largely to reasons as given by one of the roads in reply to the circular, as follows: "Our reasons for taking up the piston valve are that with the increased size of engines and steam pressure the ordinary balance 'D' slide valve increases in size proportionately, and while we may balance the valve in the same ratio as the valves on the smaller engines, the difference in unbalanced surface increases with the size of the engine. This increases the wear on the valve and link motion, eccentrics and straps, and increases the work necessary on the part of the engineman to handle the engine." The foregoing reasons probably cover the situation, the Lake Shore stating that on a very careful test an economy of about five per cent was shown, which they considered due to back pressure and perhaps slightly to decrease of amount of compression.

Among the defects, as given for piston valves, the most general are difficulty in lubrication and maintenance of relief valves, broken packing rings, edges of grooves in spool breaking, liability to blow, inability to keep steam tight and excessive wear of bushings at short stroke. In addition to this, the Lake Shore calls attention to the fact that it finds in connection with the piston valve, considerable trouble with main driving box. This is also the experience of another road, it being found that main driving boxes wear very rapidly so as to have side play and pound, making it necessary to rebore very frequently. In a letter to the committee, which the author did not desire to have published in connection with his signature, the question as to lubrication when drifting is brought up, and he states that on the road with which he is connected it is a very serious problem to lubricate the piston valve under such conditions.

In reply to question as to with which type of valve the wear and tear is

greatest, the majority of replies state that it is less on the piston valve. One road qualifies this by saying that it depends on conditions, and that if the latest type of balance valve is used the wear and tear is decidedly less with the slide valve. Another road states that it is about equal, while many give no opinion whatever, and one road states that the wear and tear is much greater on the piston valve.

Only one road replies as to the efficiency due to worn rings for varying mileages, the Burlington & Missouri River Railroad in Nebraska stating that if the piston valve is put up properly and regularly inspected there will not be any appreciable loss after making forty-five thousand miles, but otherwise the loss through leakage of steam will be so noticeable after making fifteen thousand miles that the engine would not be in very good condition.

As to which of the rings are most responsible for decreased efficiency due to wear there seems to be a decided difference of opinion. Some roads state the exhaust ring and some other roads state the steam ring, while the majority state either no data or no opinion.

Four general designs of bushing seem to be in general use — the continuous bushing with straight bridges, the continuous bushing with diagonal bridges, sectional bushing with straight bridges and sectional bushing with diagonal bridges. There does not seem to be any decided opinion as to which is the better type. In connection with the continuous bushing, an interesting suggestion is contributed by the Chicago & Northwestern Railway, in which they state that they prefer a single bushing and one having the fits at the two ends slightly different so as not to have to force the bushing the full length of cylinder. The use of the diagonal bridges probably reduces the liability of broken packing rings, and also will probably give a little more wear, but it is questionable if the increased cost over the straight bridge warrants the use of this type. With simple engines using the piston valve the general preference seems to be for two bushings, one at either end of the piston valve chamber, although there are several cases where the continuous bushing is used on the simple engine. With the compound engine it becomes desirable on account of the number of ports to use the continuous bushing, and this type is used exclusively on the Vauclain compound piston valve.

In a majority of cases a knuckle joint or Scotch yoke is used. In some cases, however, it is not used where the valve stem is long. There seems to be no doubt that for best results with wear of packing rings and valves some device should be used so as to remove all tendency for valve wearing within the valve chamber, and to resolve all force acting on the valve into one parallel with the valve stem.

On the later compound engines with the piston valve, of the Vauclain type, a hollow valve stem with extension for relief valve supported in both front and back heads seems to be generally used. On simple engines, in some cases an extension is also used, but the opinion that same is necessary is not general, it being stated that equal results are sometimes obtained

without the extension. The first method mentioned for the support of valve with the hollow stem is shown in Fig. 12, Section I of Appendix. Another method is shown in Fig. 23, which consists essentially of a horn in front chamber head carrying an extension on the valve stem, but all contained inside of the valve chamber. This type seems very satisfactory for the purpose intended, namely, relieving the valve chamber from wear caused by weight of the valve itself.

In the Appendix which accompanies this report will be found the tests referred to on various types of valves and valve bushings, which illustrate very thoroughly the practice of this country as regards the piston valve. Some of the modifications as to design of ring will be found very interesting. Section I shows different types of valves submitted; Section II, the different types of bushings used; Section III, test of a special type of packing ring by the C. M. & St. P.; Section IV, circulating pipe and test of same as furnished by the Southern Pacific Company; Section V, C. B. & Q. tests of valve friction; Section VI, tests of piston valves from paper presented at Richmond Railroad Club.

From the replies to some of the questions it is very evident that little or no data is available on some of the subjects brought up in connection with the piston valve. Your committee, therefore, recommends:

First: That tests be made to determine the amount of loss of steam due to worn packing rings. Such tests should include the various types of rings illustrated in the report.

Second: That tests be made to determine whether the steam or the exhaust rings are the most responsible for the decreased efficiency due to wear.

Third: That the question of proper lubrication of piston valves when drifting be more thoroughly investigated.

Fourth: The attention of the committee being called to the question of valve setting in connection with the piston valve, after it was too late to include it in the circular, by one road stating that with identical valve motions, to obtain equal work, modifications in the piston valve setting must be made, it is suggested that further investigation be made along this line.

F. F. Gaines, Chairman,
R. P. C. Sanderson,
F. H. Clark,
Committee.

Wilkesbarre, Pa., May 18, 1903.

[redacted]

APPENDIX.

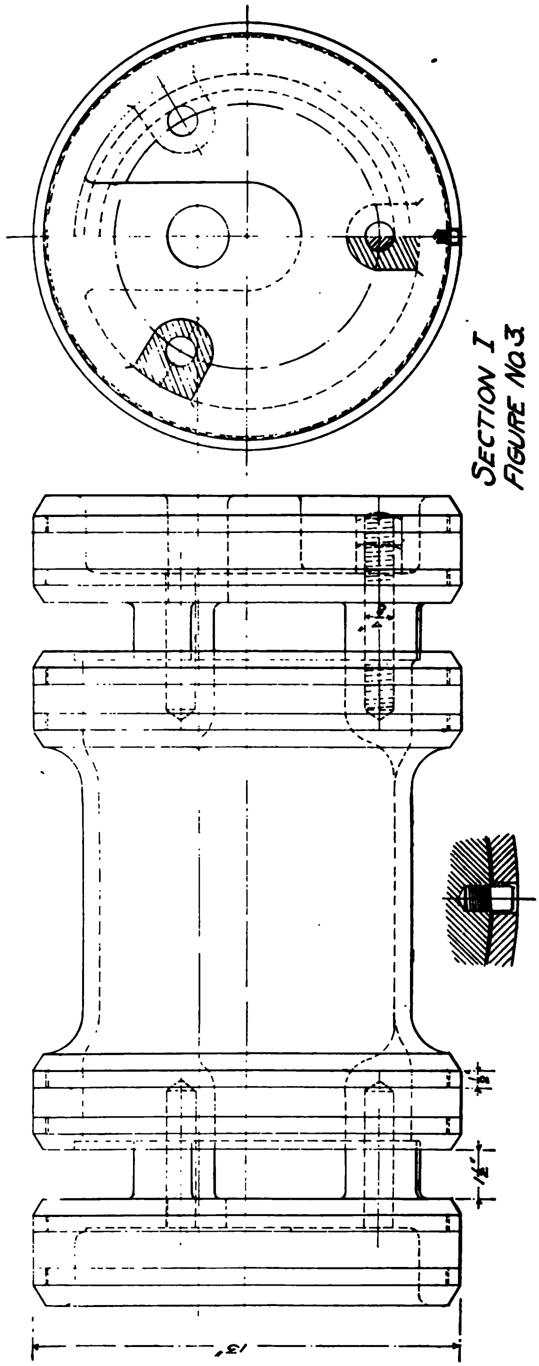
SECTION I—FIGS. 1 to 25 INCLUSIVE.

APPENDIX.

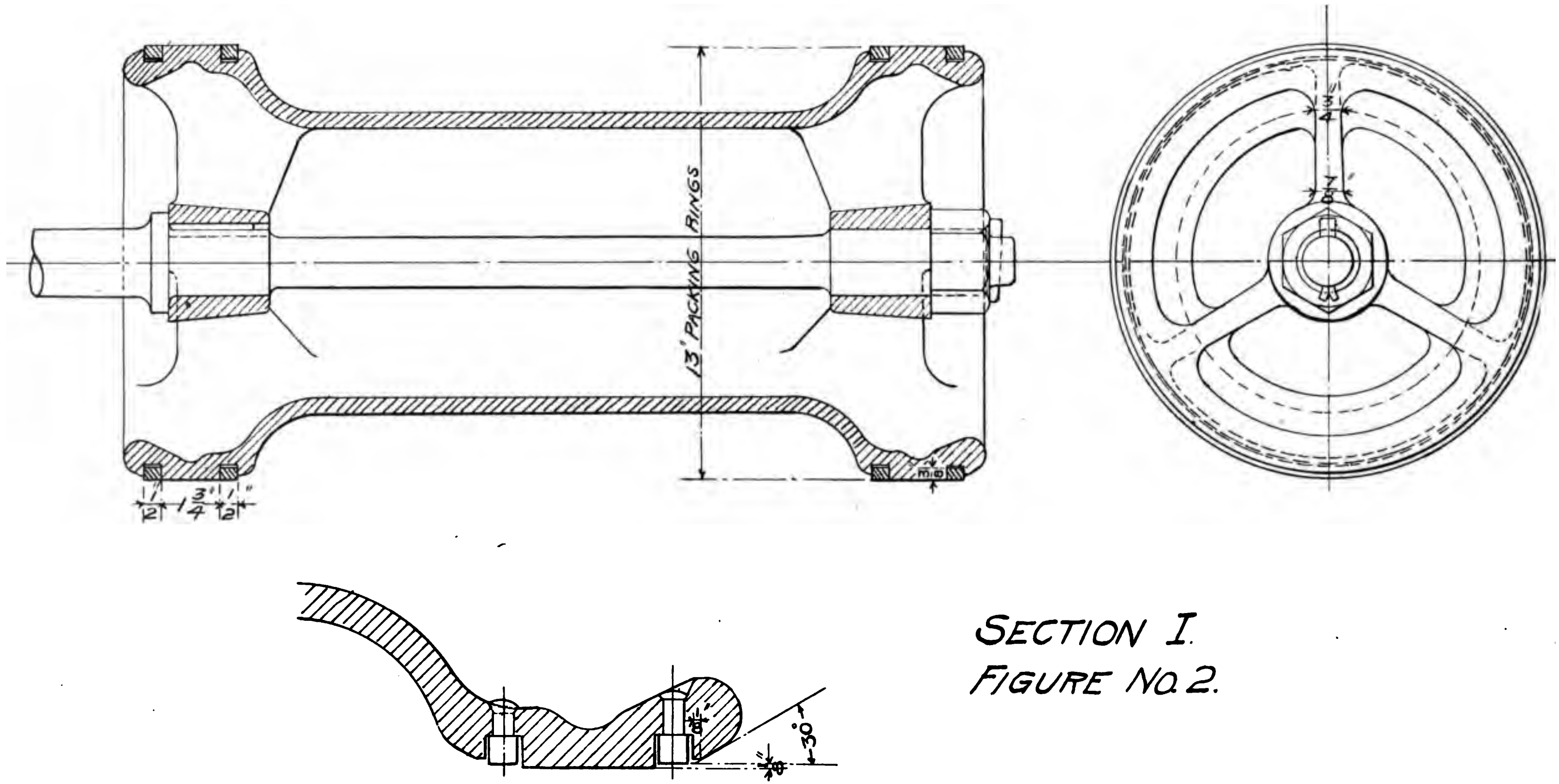
SECTION I—FIGS. 1 to 25 INCLUSIVE.

APPENDIX.

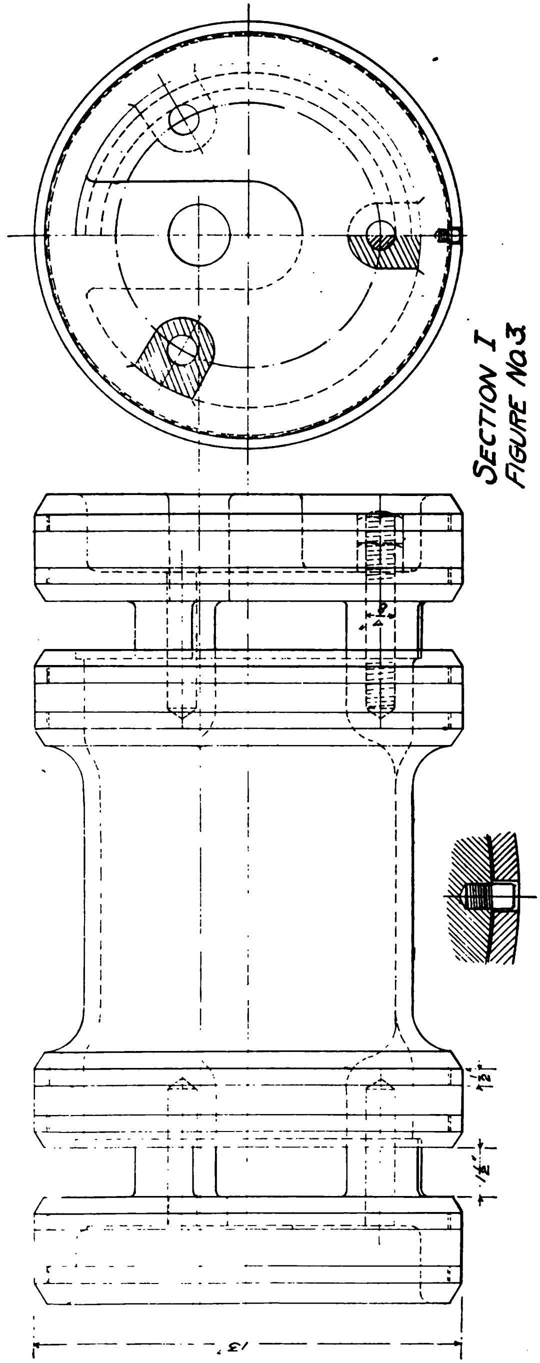
Section I—Figs. 1 to 25 Inclusive.



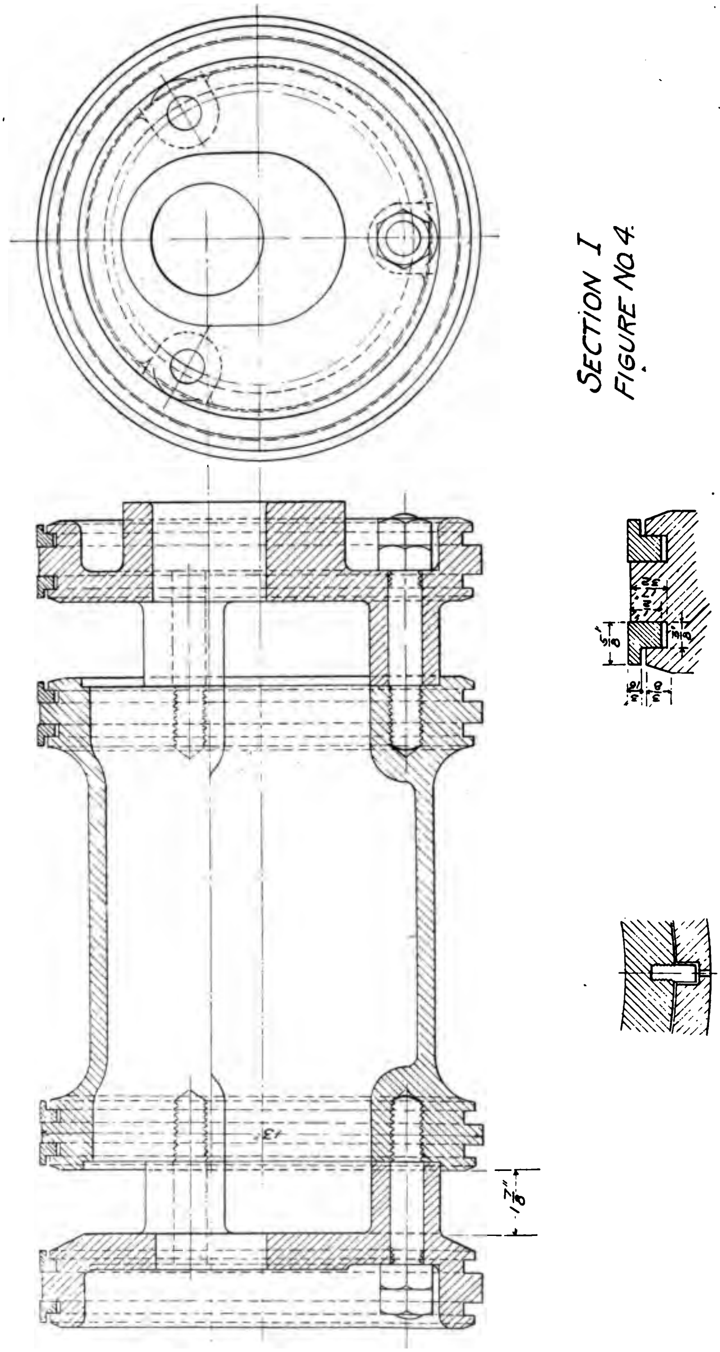
SECTION I
FIGURE No. 3



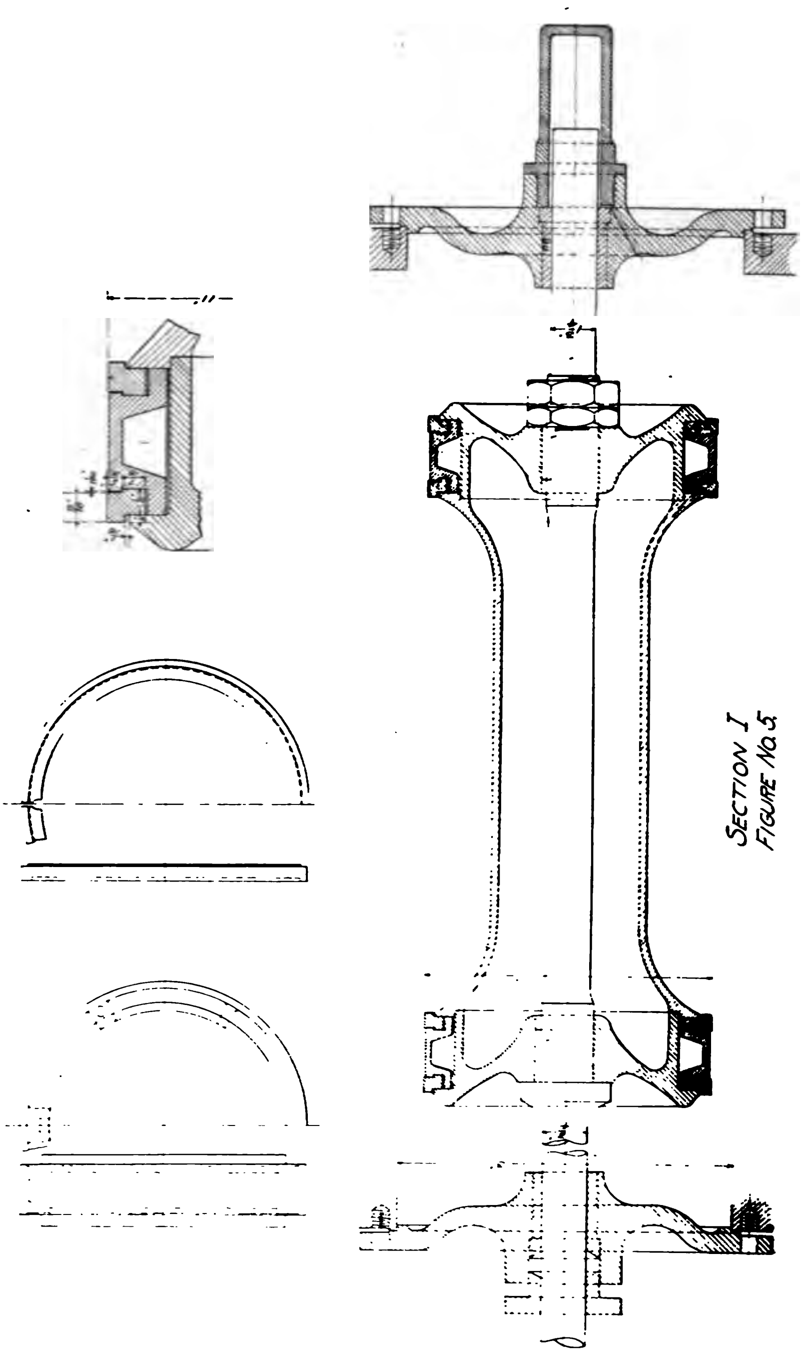
SECTION I.
FIGURE NO. 2.



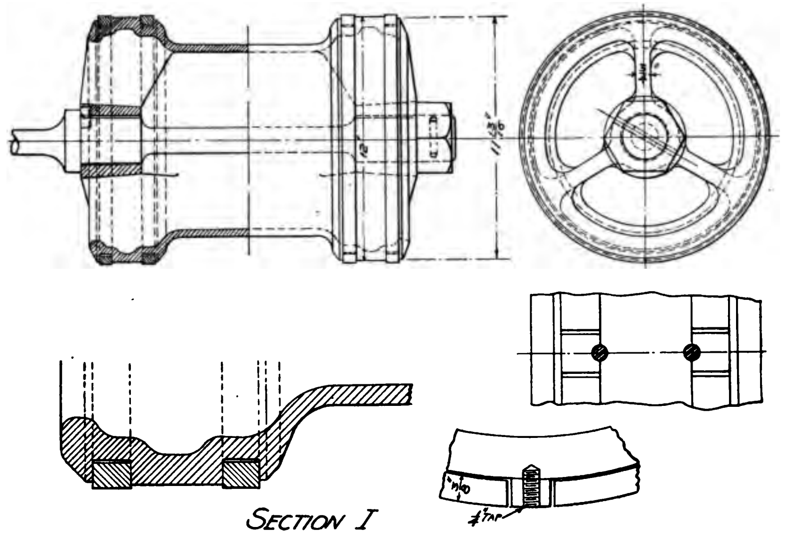
SECTION I
FIGURE No. 3



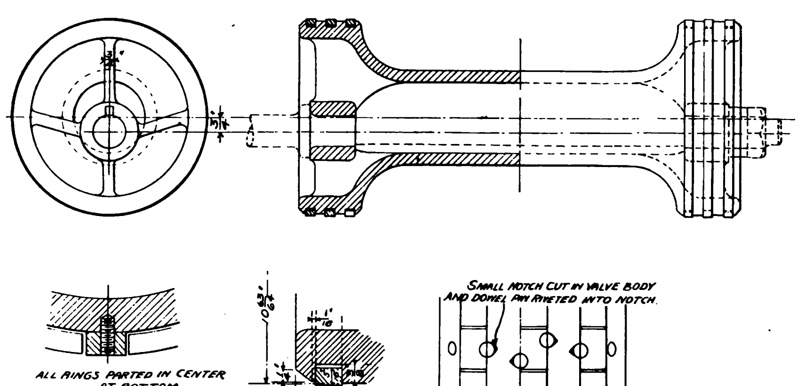
SECTION I
FIGURE No 4.



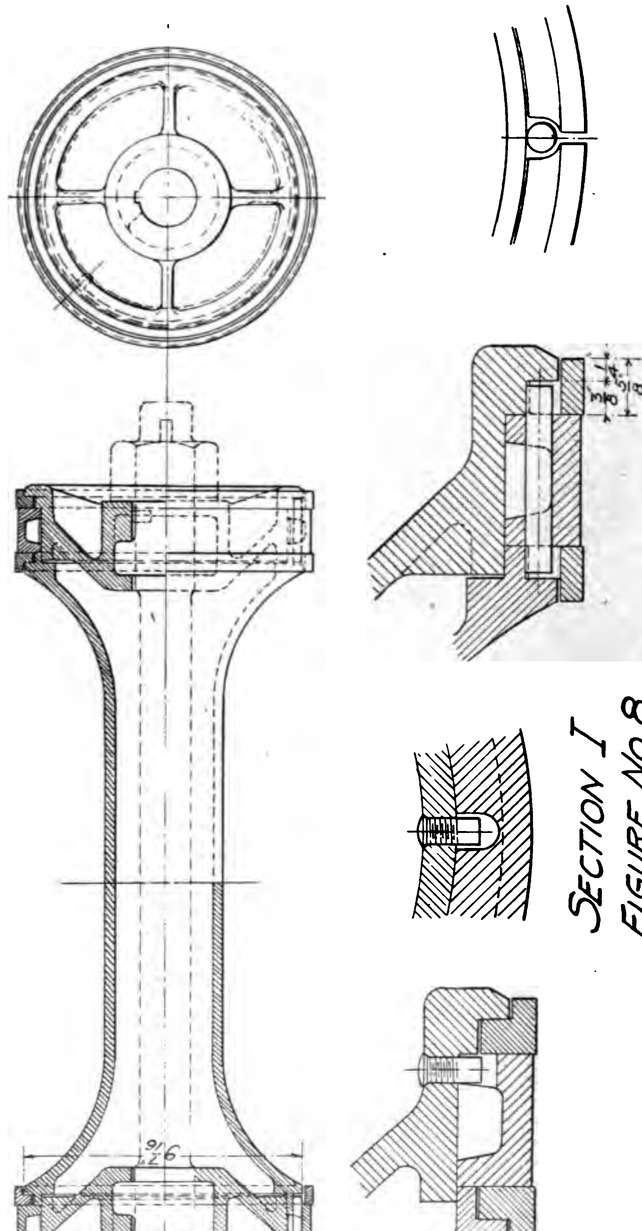
SECTION I
FIGURE NO. 5



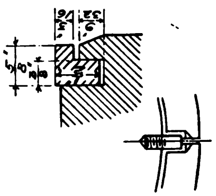
SECTION I
FIGURE NO. 6.

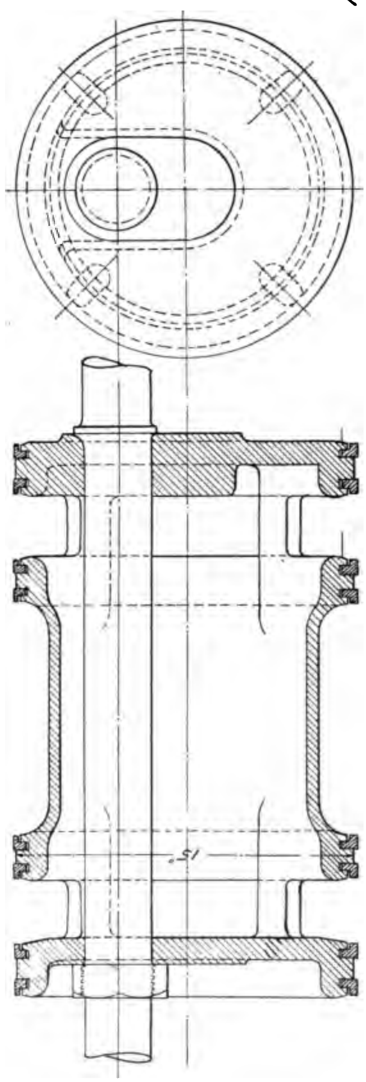


SECTION I
FIGURE NO. 7.

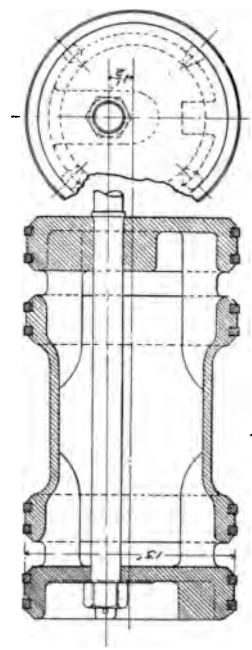


SECTION I
FIGURE No. 8.





SECTION I
FIGURE No. 9



SECTION I
FIGURE No. 10

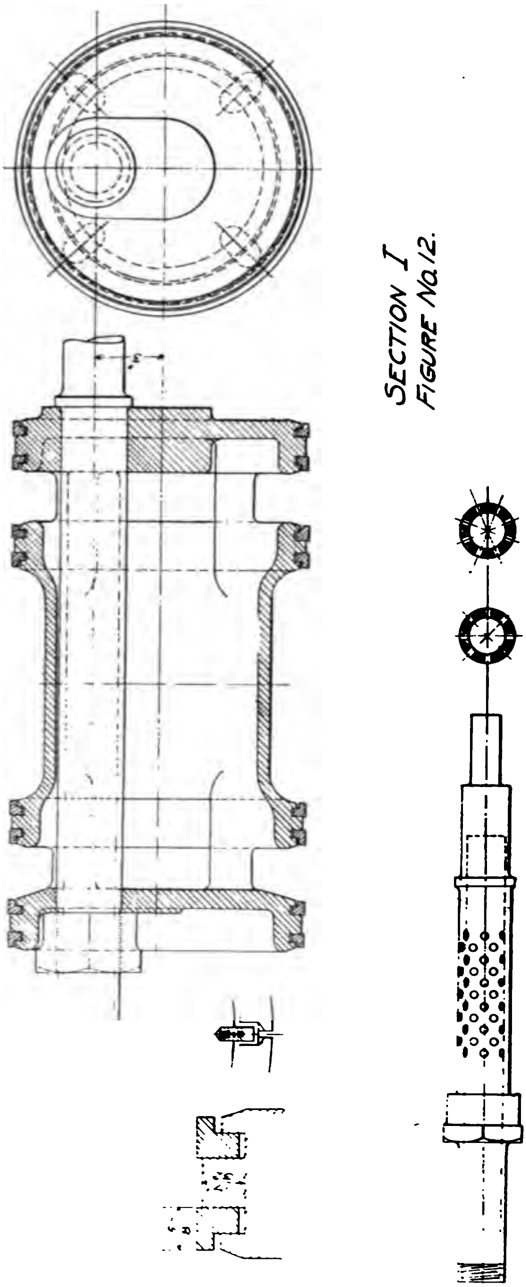


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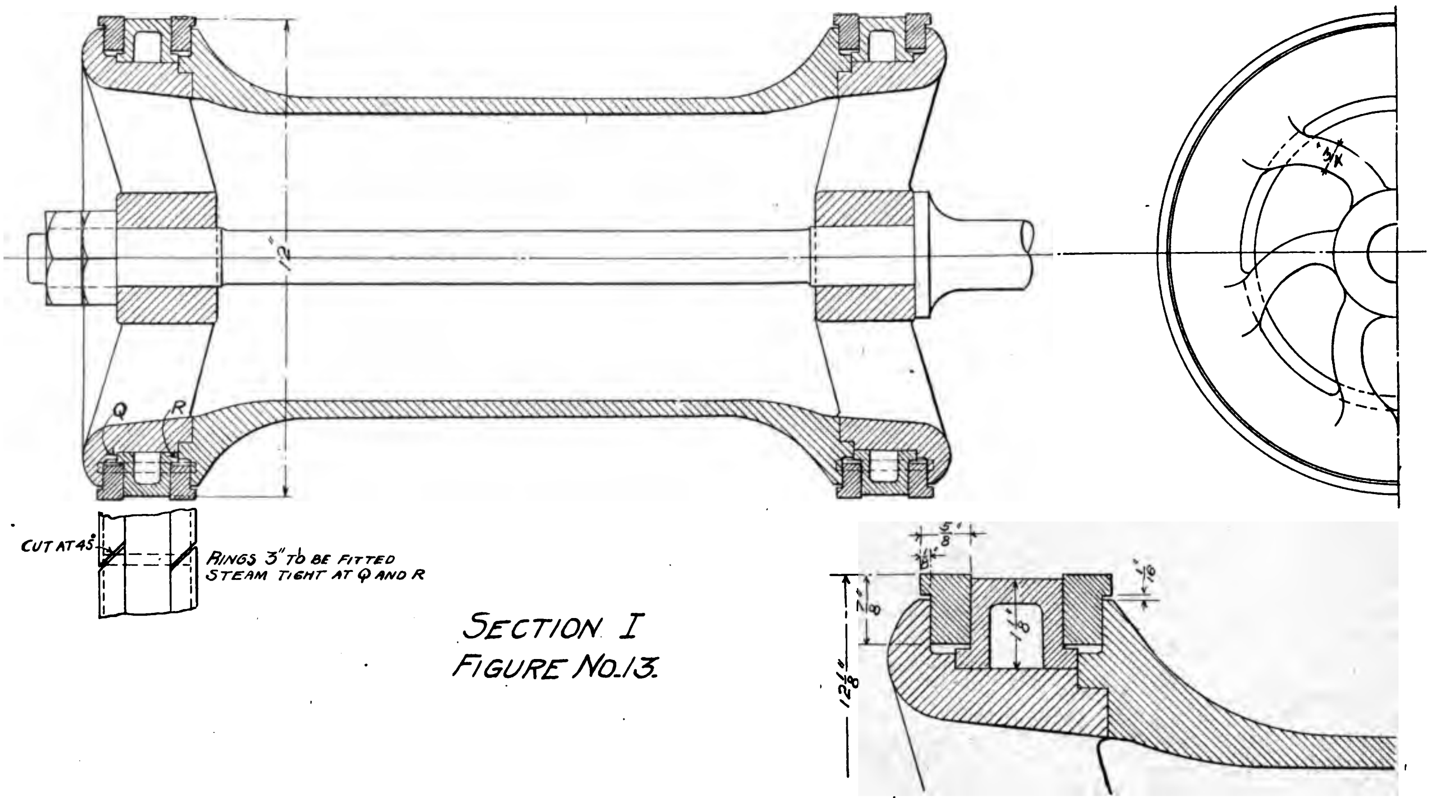
FIGURE No. 12.



SECTION I
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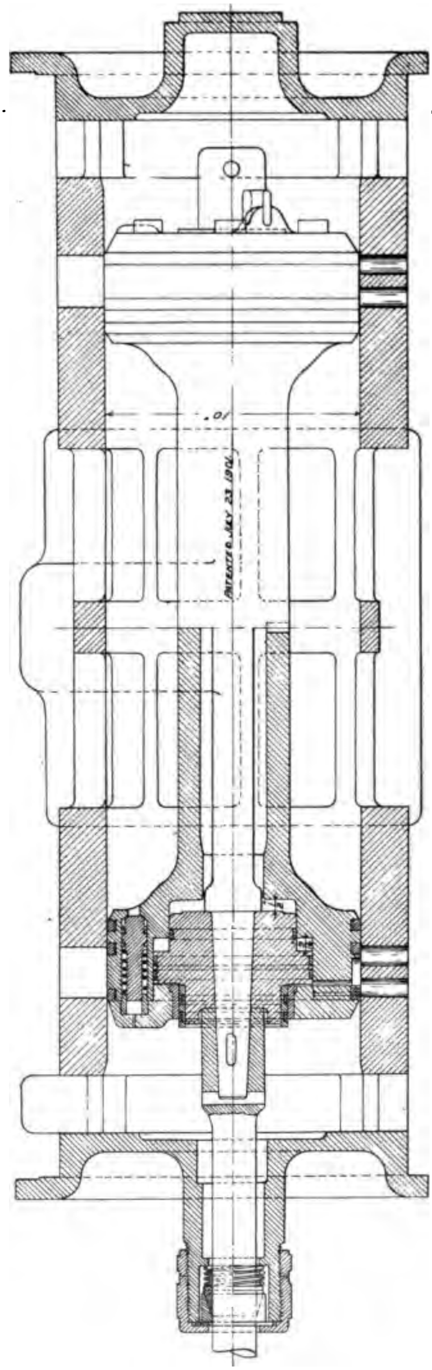
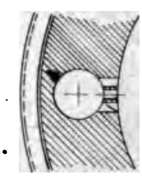
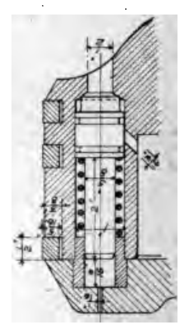


SECTION I
FIGURE No 18





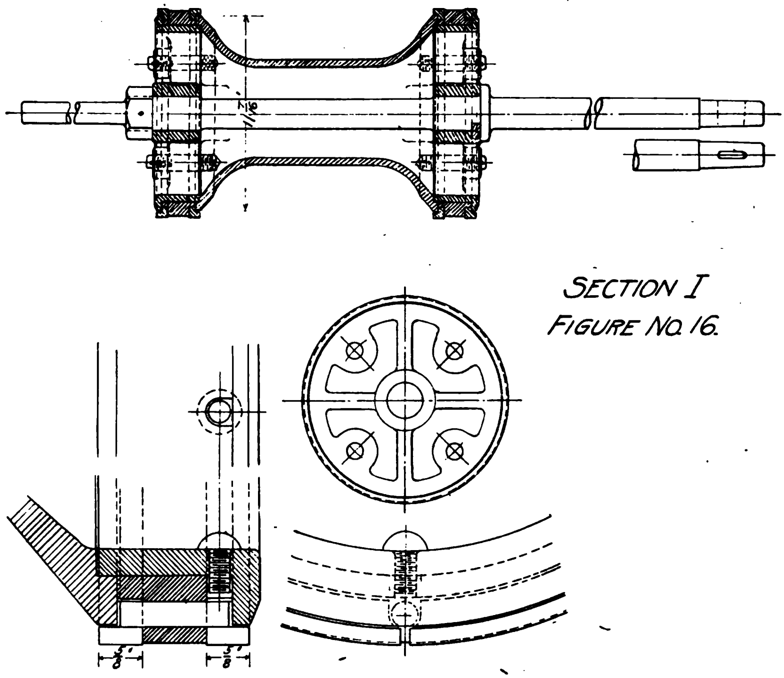


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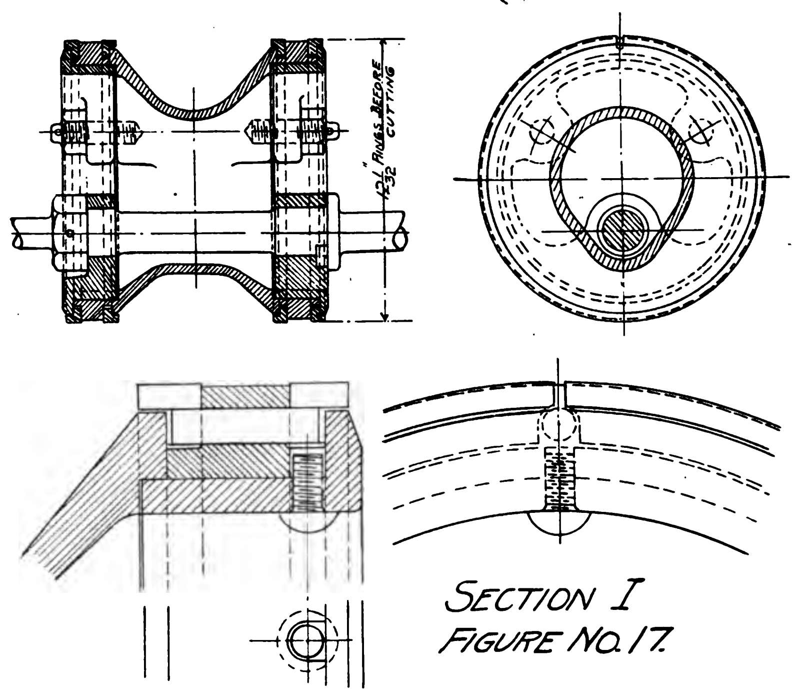
FIGURE NO. 16.



SECTION I
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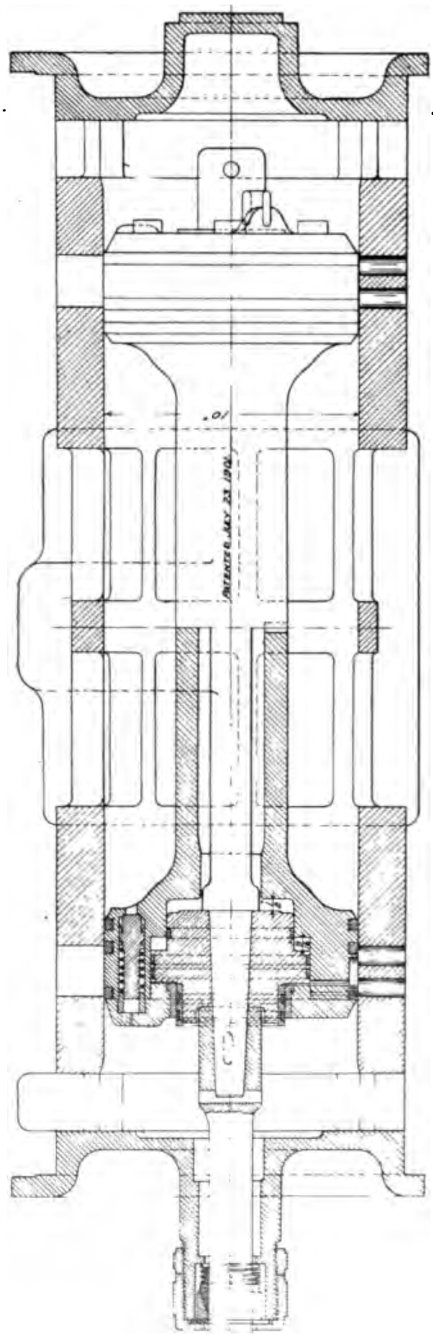
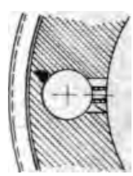
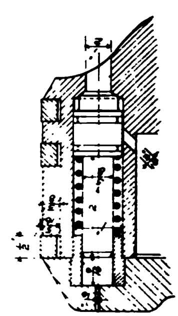
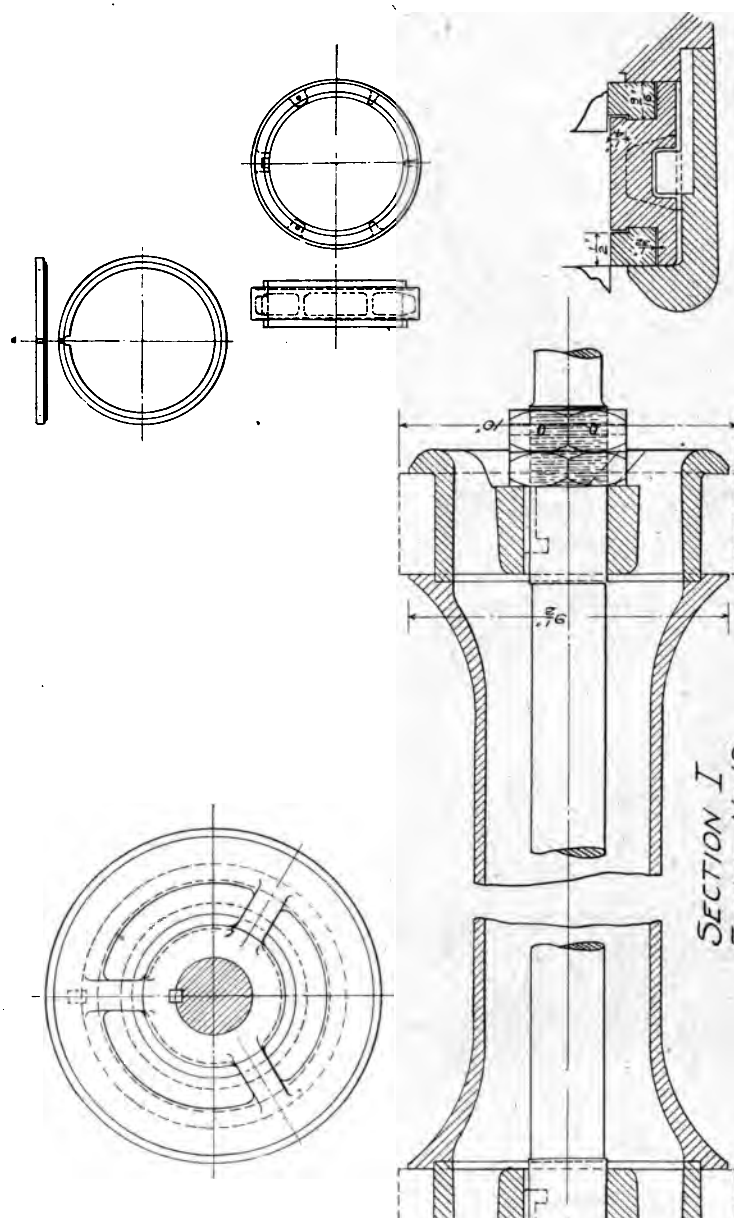


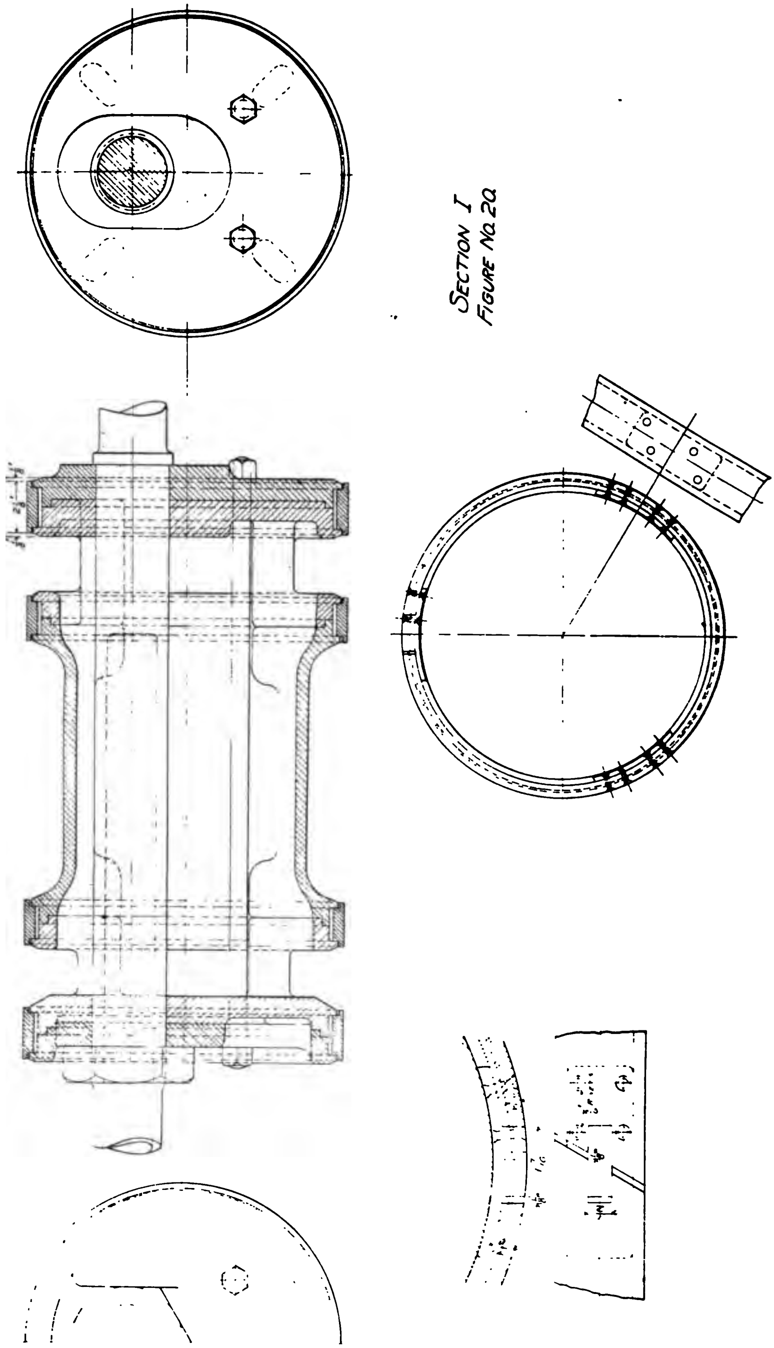
SECTION I
FIGURE No 18



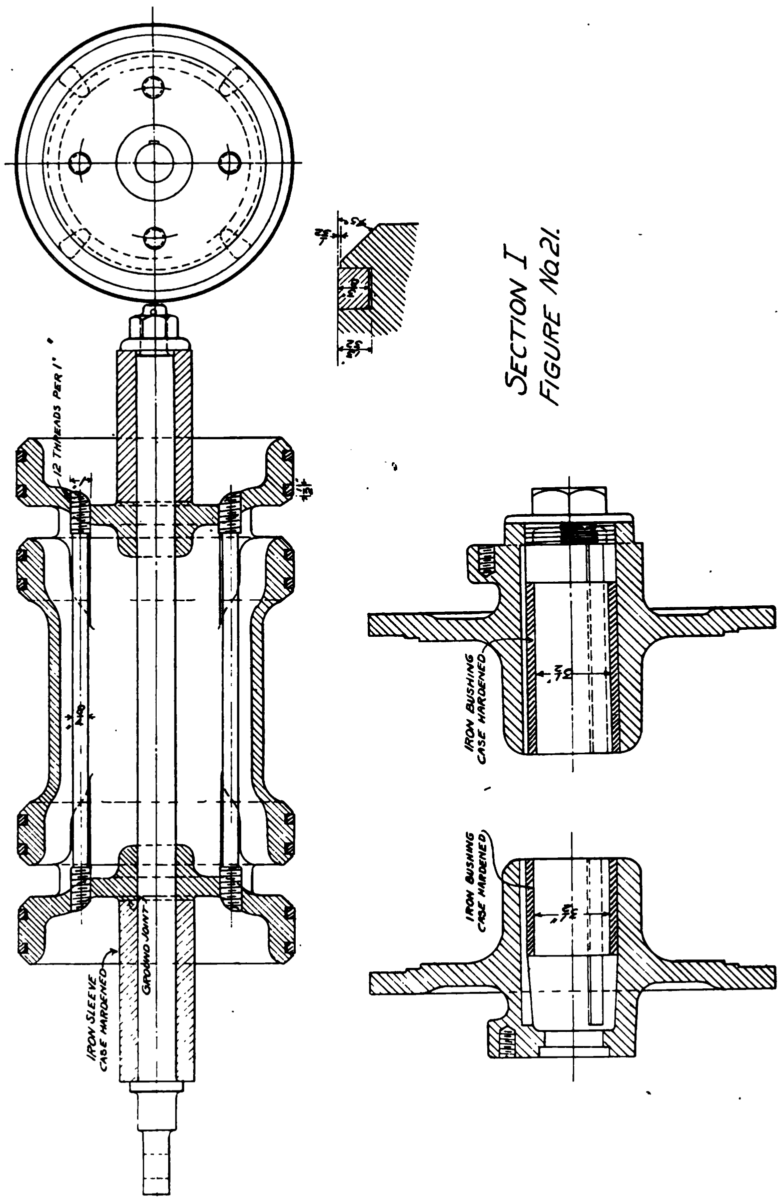




SECTION I
FIGURE No. 19

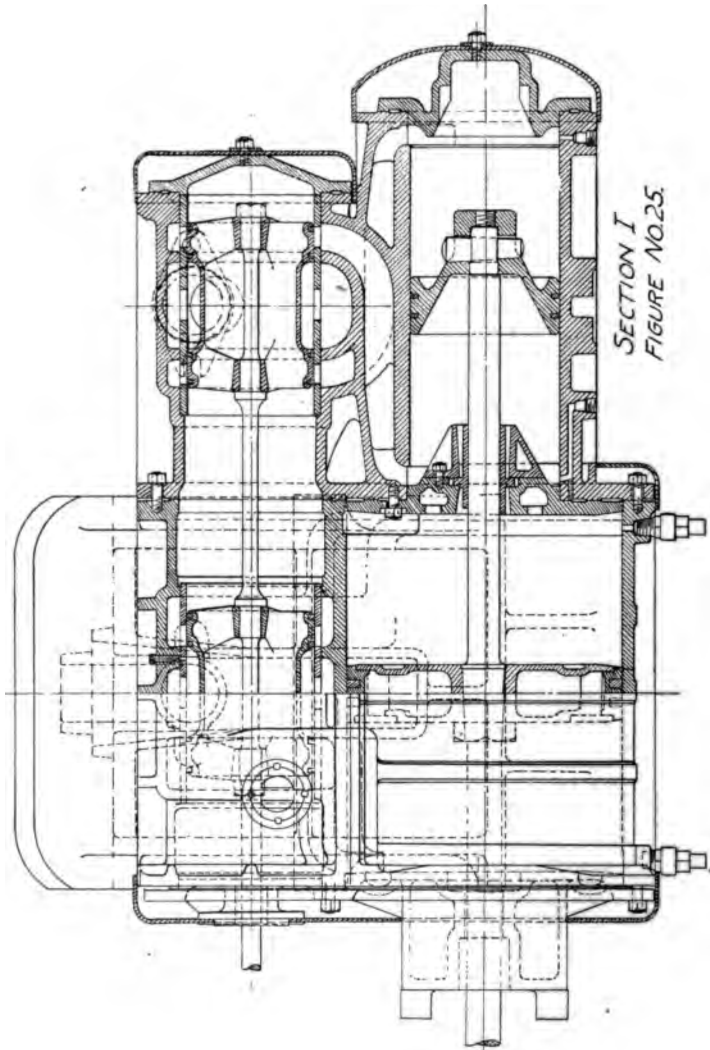


Section I
Figure No 2a

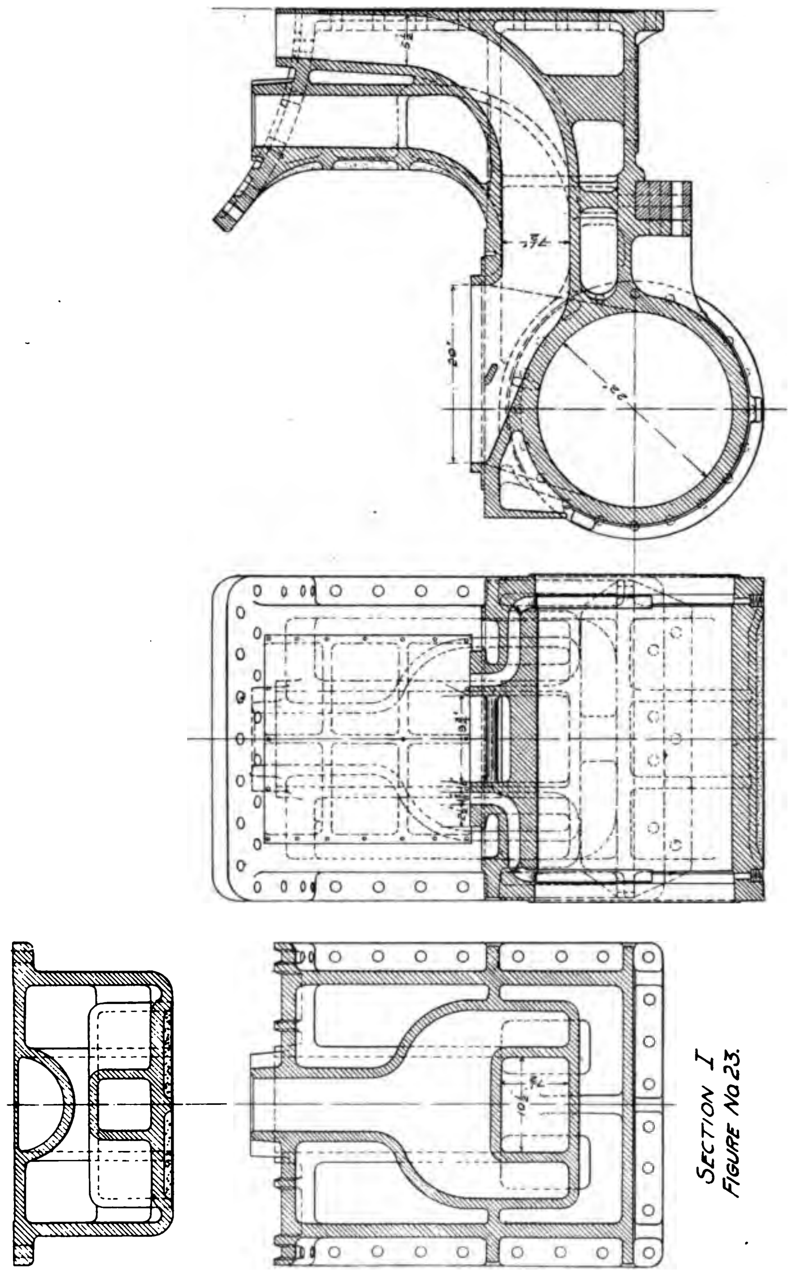


SECTION I
FIGURE No. 21.

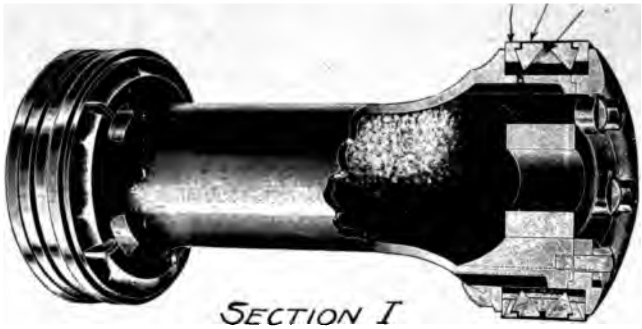
SECTION I
FIGURE No. 24



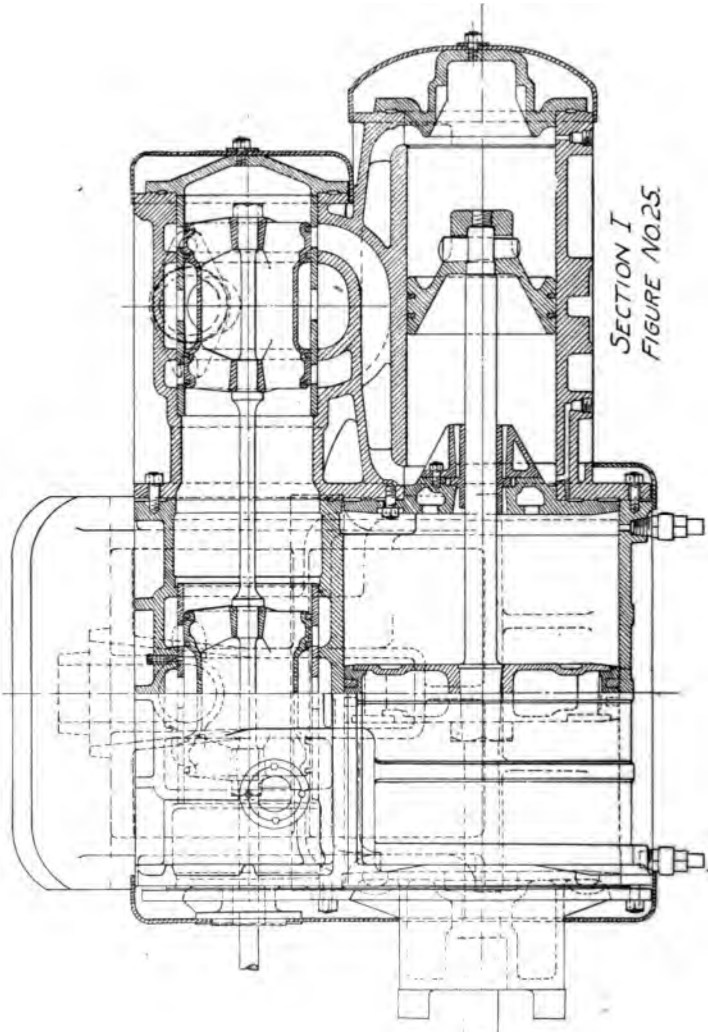
SECTION I
FIGURE No. 25



SECTION I
FIGURE No 23.



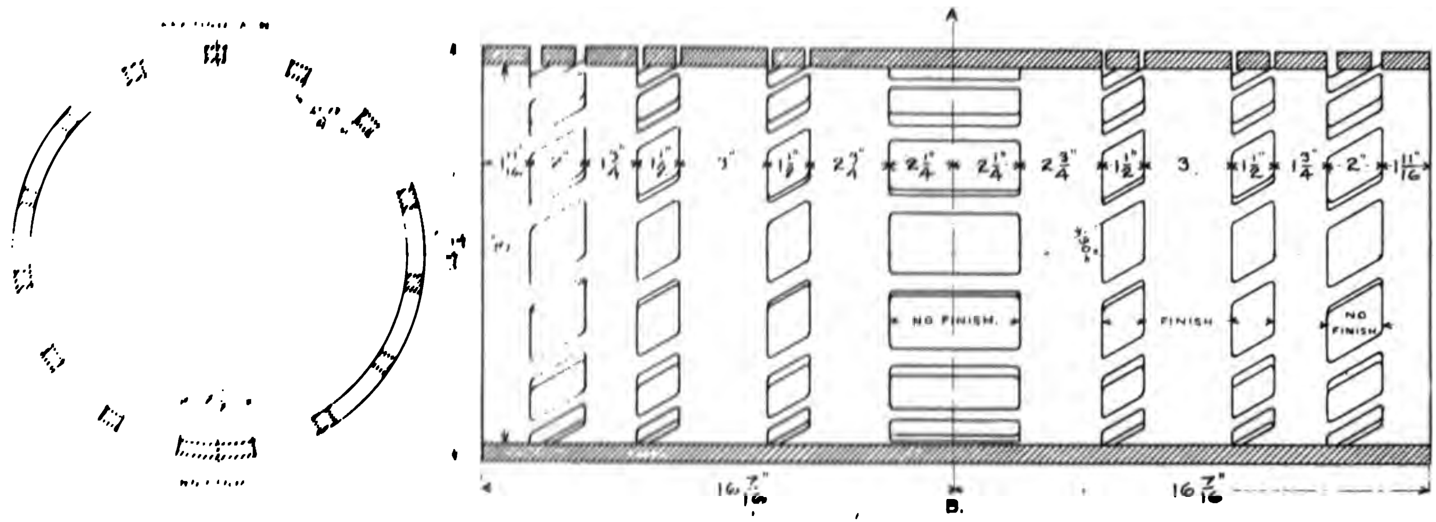
SECTION I
FIGURE No. 24



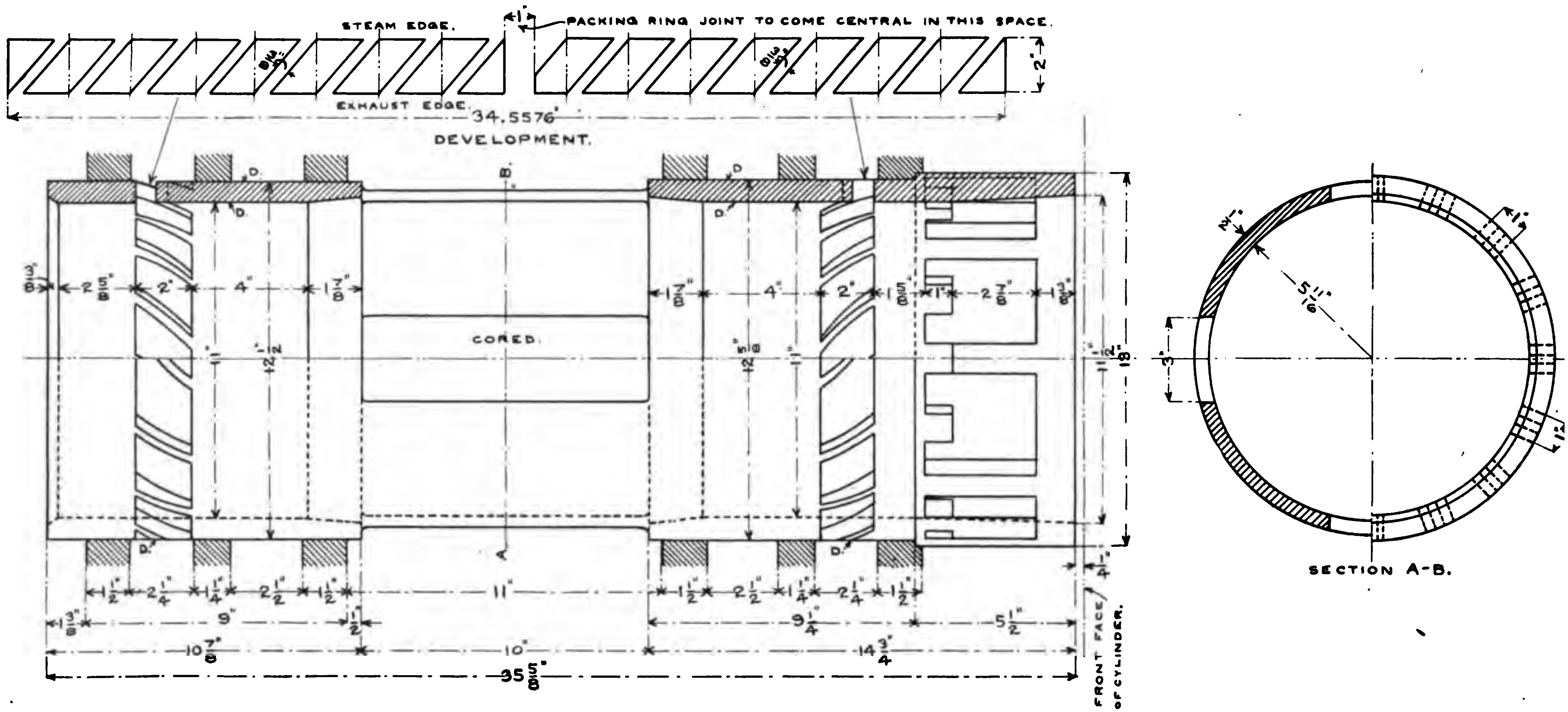
SECTION I
FIGURE No. 25

APPENDIX.

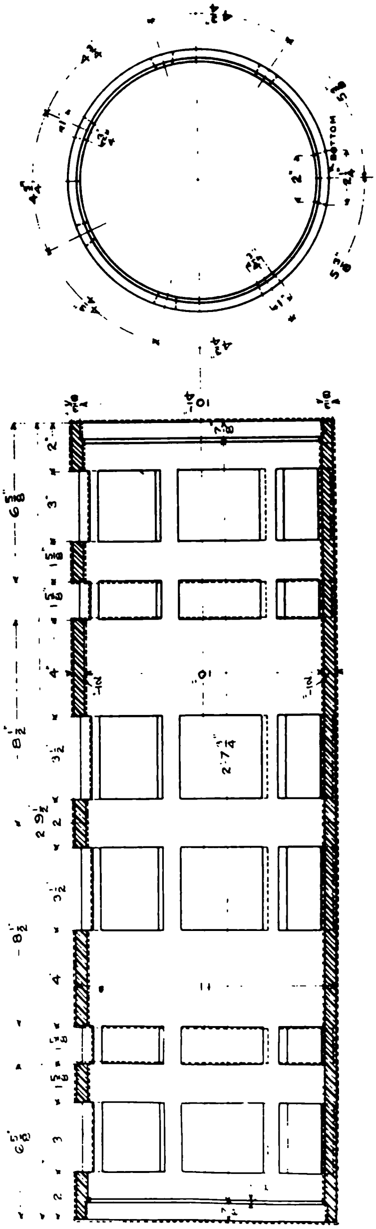
Section II—Figs. 1 to 10 Inclusive.



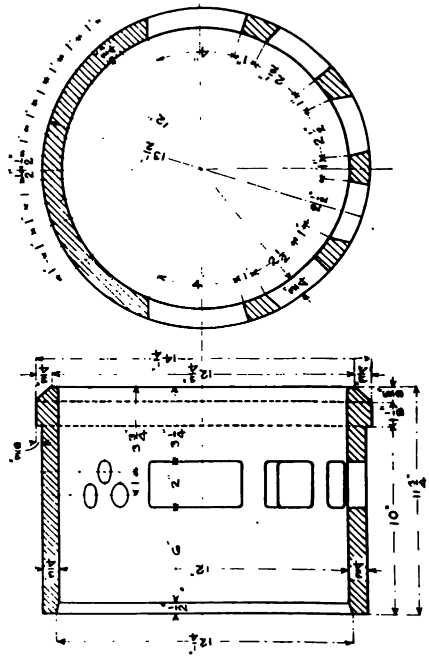
SECTION II Fig. 1.



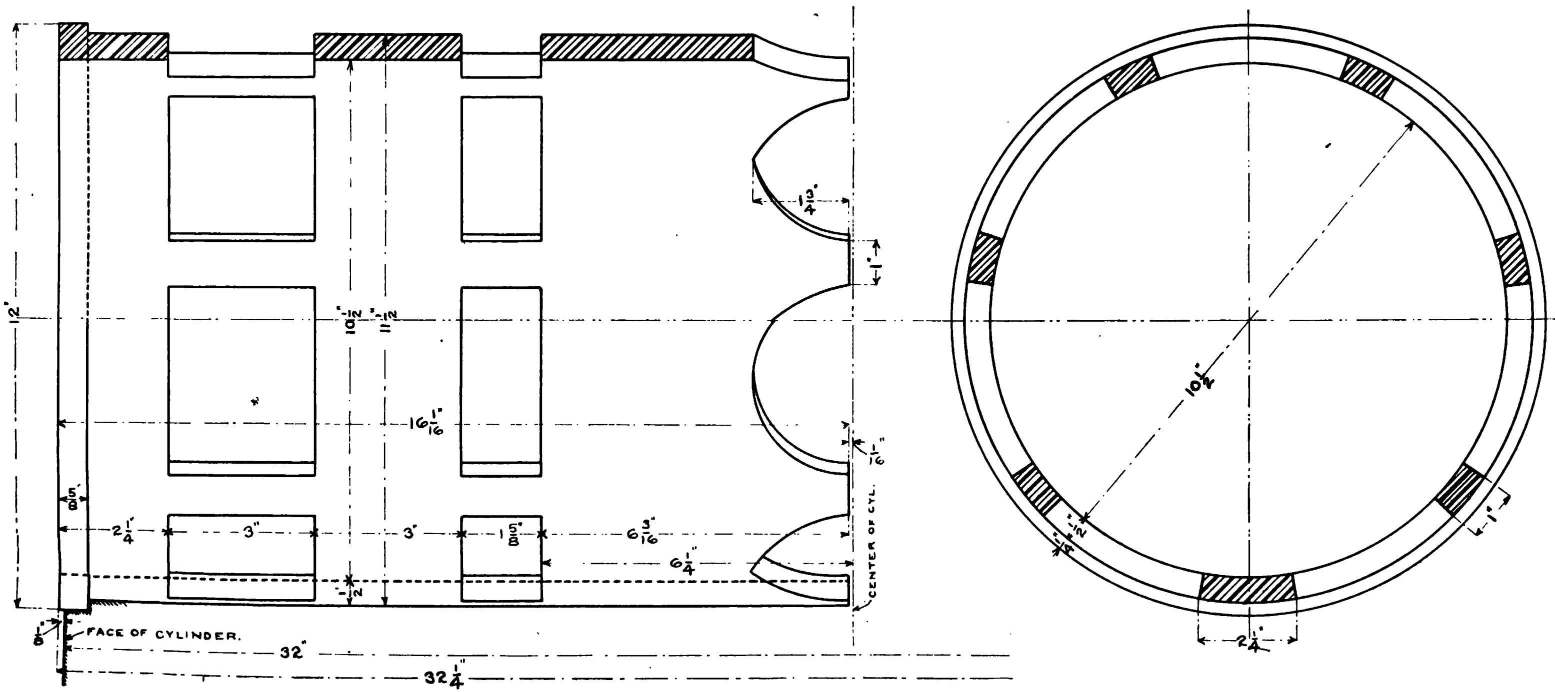
SECTION II—FIG. 2.



SECTION II—FIG. 6.



SECTION II—FIG. 7.



SECTION II—FIG. 10.

APPENDIX.

Section III.

SECTION III.

C. M. & St. P. Ry. Test of Miller & Baldwin Valves.

— LOG OF TEST —

MAY 3RD 1902.

ENGINE 317 — BALDWIN COMPOUND — 15" × 25" × 26"
TEN WHEEL CLASS
DIAMETER OF DRIVERS — 5'-8"
WEIGHT ON DRIVERS — 123275 LBS
CAPACITY OF TANK — 6000 GAL.
BOILER PRESSURE — 200 LBS

VALVES — DIAGONAL BUSHING RIGHT SIDE (MILLER VALVE)
STRAIGHT " LEFT " (BALDWIN VALVE)
FULL TRAVEL OF VALVES — $5\frac{13}{16}$
LAP, OUTSIDE, HIGH PRESS. CYL — $\frac{3}{4}$.
" " LOW " " — $\frac{5}{8}$.
" INSIDE, HIGH " " — $\frac{1}{8}$.
" " LOW " " — $\frac{1}{4}$ NEG.
LEAD, HIGH PRESS CYL. ------
" LOW " " ------
DIAMETER OF PISTON RODS ---- 3.75"

ENGINE CONSTANTS —

HIGH PRESSURE CYL	F.	....	.0116
" "	B.	....	.01085
LOW "	F.	....	.0323
" "	B.	....	.0315

TIME OF RUN ---
LEFT -- MUSKEGO YARDS ------ 12.14 P.M.
ARRIVED - PORTAGE " ------- 8.30 P.M.

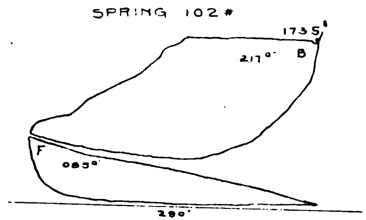
TRAIN —
57 EMPTIES 3 LOADS.

CARDS		
	1-11 INC.	FRONT H.P. & BACK L.P.
	12-36 "	BACK H.P. & FRONT L.P.
	37-43 "	FRONT H.P. & BACK L.P.
	44-60 "	BOTH ENDS H.P. & L.P.

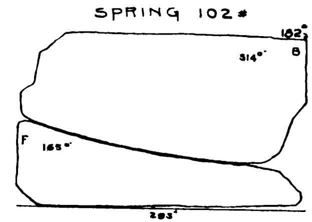
CARDS ON LEFT SIDE TAKEN BY J. F. DEVOY.
" " RIGHT " " " G. S. GOODWIN.
RECORD IN CAB KEPT BY ---- J. R. THOMPSON.
SPEED OBTAINED BY COUNTING REV OF DRIVERS.

SECTION III.

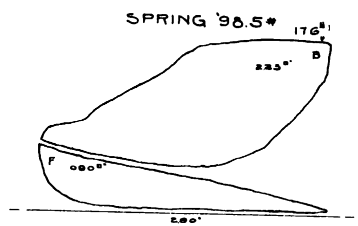
C. M. & St. P. Ry. Test of Miller & Baldwin Valves.



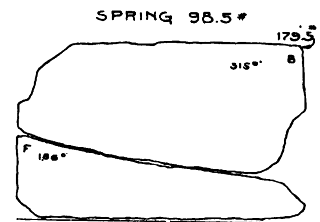
CARD No 16 RIGHT
THROTTLE ½ NOTCH 1 BOIL. PRESS. 195#
CUT OFF 12"
M.E.P. H.P. CYL. F .... B 76.3
M.E.P. L.P. CYL. F 30 B ....
I.H.P. H.P. CYL. F .... B 49.6 TOTAL 99.2 } 215.2
I.H.P. L.P. CYL. F 58 B .... TOTAL 116 }
REV PER MIN. 120 MILES PER HR. 24.5



CARD No 21 RIGHT
THROTTLE ½ NOTCH 9 BOIL. PRESS. 185#
CUT OFF 21.8
M.E.P. H.P. CYL. F .... B 109.4
M.E.P. L.P. CYL. F 57.5 B ....
I.H.P. H.P. CYL. F .... B 35.6 TOTAL 71.2 } 182.4
I.H.P. L.P. CYL. F 55.6 B .... TOTAL 111.2 }
REV. PER MIN. 60 MILES PER HR. 12.1



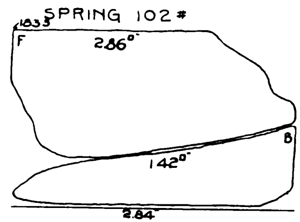
CARD No 16 LEFT
THROTTLE ½ NOTCH 1 BOIL. PRESS. 195#
CUT OFF 12.41"
M.E.P. H.P. CYL. F .... B 75.7
M.E.P. L.P. CYL. F 30.6 B ....
I.H.P. H.P. CYL. F .... B 49.1 TOTAL 98.2 } 216.6
I.H.P. L.P. CYL. F 59.2 B .... TOTAL 118.4 }
REV PER MIN. 120 MILES PER HR. 24.5



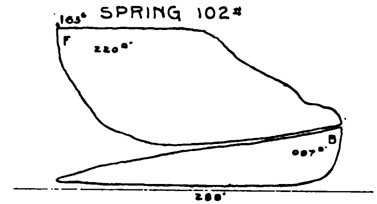
CARD No 21 LEFT
THROTTLE ½ NOTCH 9 BOIL. PRESS. 185#
CUT OFF 21"
M.E.P. H.P. CYL. F .... B 106
M.E.P. L.P. CYL. F 52.6 B ....
I.H.P. H.P. CYL. F .... B 34.5 TOTAL 69 } 170.6
I.H.P. L.P. CYL. F 50.8 B .... TOTAL 101.6 }
REV. PER MIN. 60 MILES PER HR. 12.1

SECTION III.

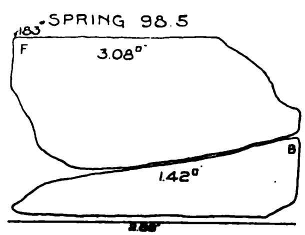
C. M. & St. P. Ry. Test of Miller & Baldwin Valves.



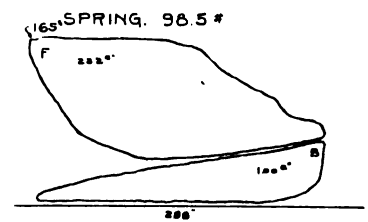
CARD No 41 RIGHT
THROTTLE ½ NOTCH 6 BOIL. PRESS. 190#
CUT OFF 18.6
M.E.P H.P CYL. F 103 B
M.E.P L.P CYL. F B 51
I.H.P H.P CYL. F 35.8 B TOTAL 71.6 } 167.8
I.H.P L.P CYL. F B 48.1 TOTAL 96.2 }
REV. PER MIN. 60 MILES PER HR. 12.1



CARD No 43 RIGHT
THROTTLE ½ NOTCH 2 BOIL. PRESS. 170#
CUT OFF 14.5"
M.E.P H.P CYL. F 78 B
M.E.P L.P CYL. F B 34.4
I H P H.P CYL. F 48.9 B TOTAL 97.8 } 214.8
I H P L.P CYL. F B 58.5 TOTAL 117. }
REV. PER MIN 108 MILES PER HR. 22



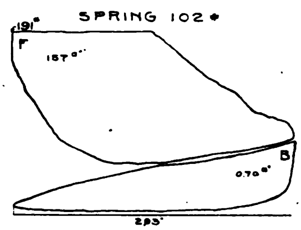
CARD No 41 LEFT
THROTTLE ½ NOTCH 6 BOIL. PRESS. 190#
CUT OFF 18.9
M.E.P H.P CYL. F 105 B
M.E.P L.P CYL. F B 48.5
I.H.P H.P CYL. F 36.5 B TOTAL 73.0 } 164.6
I.H.P L.P CYL. F B 45.6 TOTAL 91.6 }
REV. PER MIN. 60 MILES PER HR. 12.1



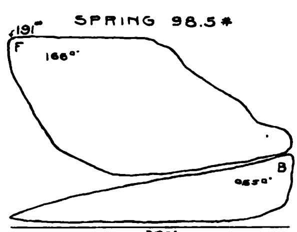
CARD No 43 LEFT
THROTTLE ½ NOTCH 2 BOIL PRESS. 170#
CUT OFF 13.2"
M.E.P H.P CYL. F 79.2 B
M.E.P L.P CYL. F B 34.2
I.H.P H.P CYL. F 49.5 B TOTAL 99.0 } 215.2
I.H.P L.P CYL. F B 58.1 TOTAL 116.2 }
REV. PER MIN. 108 MILES PER HR. 22

Section III.

C. M. & St. P. Ry. Test of Miller & Baldwin Valves.



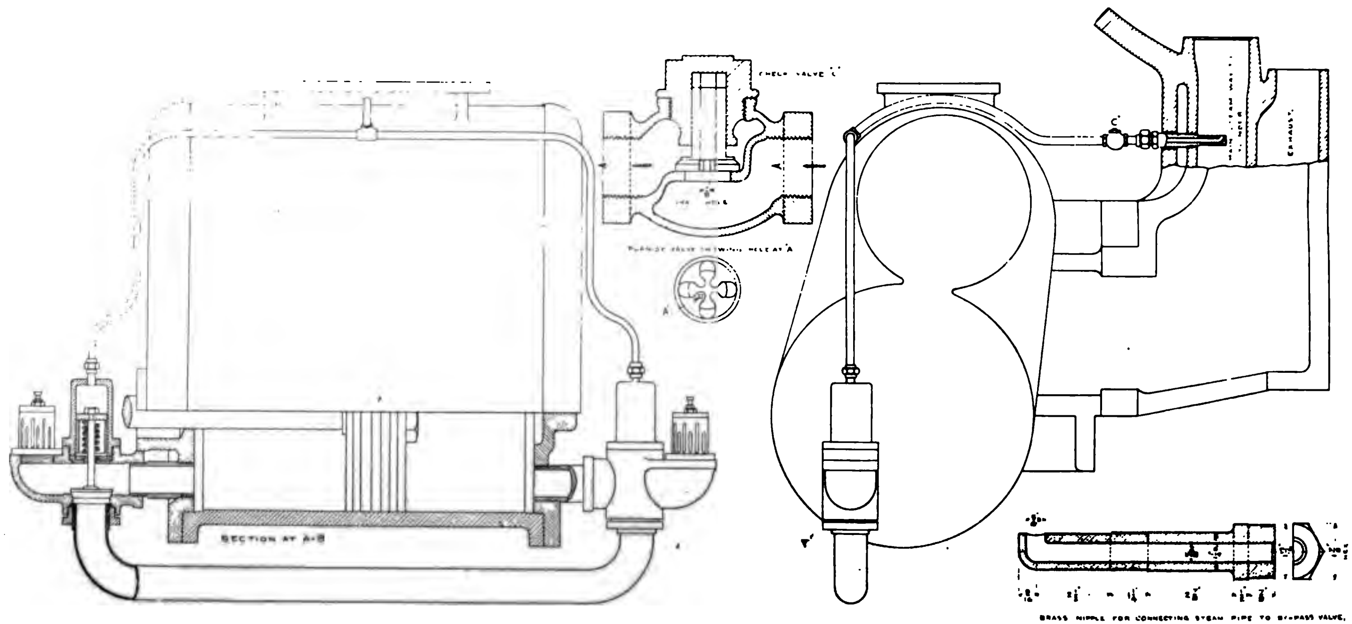
CARD Nº 3 RIGHT
THROTTLE ½ NOTCH 2 BOIL. PRESS. 200#
CUT OFF 13.7
M.E.P. H.P. CYL. F 55. B
M.E.P. L.P. CYL. F B 24.4
I.H.P. H.P. CYL. F 26.7 B TOTAL 53.4 } 117.8
I.H.P. L.P. CYL. F B 32.2 TOTAL 64.4 }
REV. PER MIN. 84 MILES PER HR. 17



CARD Nº 3 LEFT
THROTTLE ½ NOTCH 2 BOIL. PRESS. 200#
CUT OFF 14.2
M.E.P. H.P. CYL. F 55.7 B
M.E.P. L.P. CYL. F B 21.8
I.H.P. H.P. CYL. F 27.1 B TOTAL 54.2 } 111.6
I.H.P. L.P. CYL. F B 28.7 TOTAL 57.4 }
REV. PER MIN. 84 MILES PER HR. 17

APPENDIX.

SECTION IV.



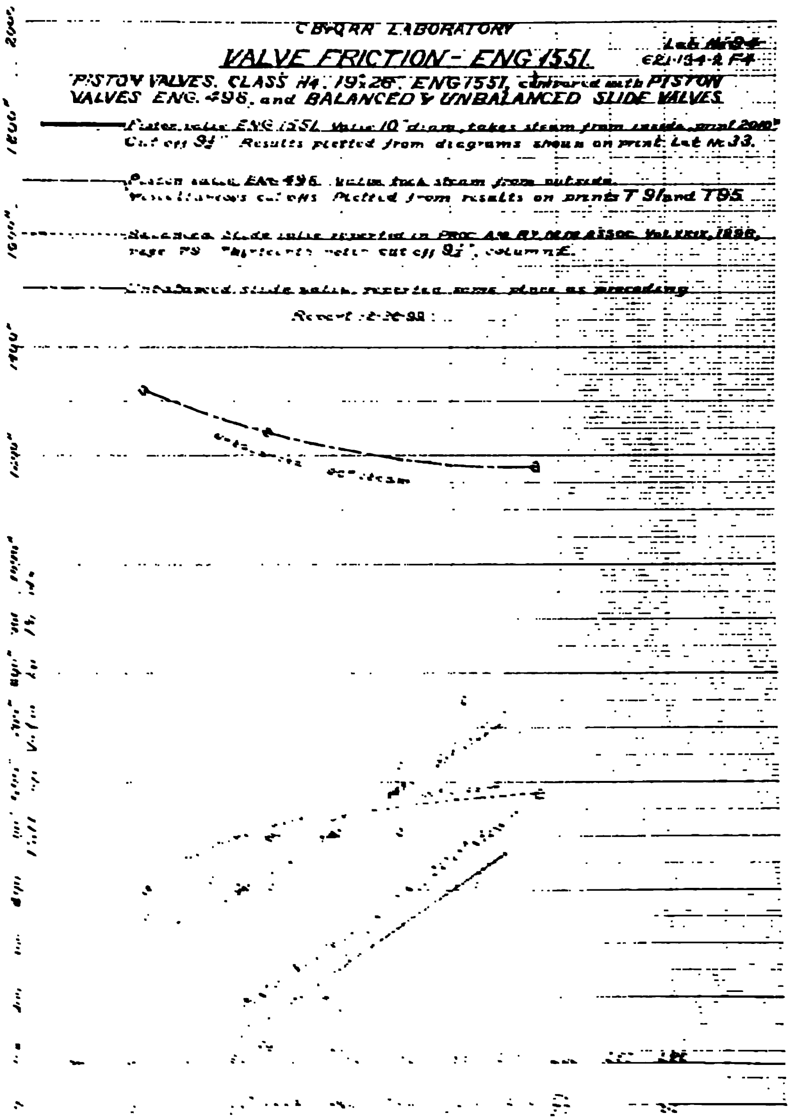
SECTION IV—So. Pac. Co. Circulating Pipe for Piston Valve Locomotives.

APPENDIX.

SECTION V.

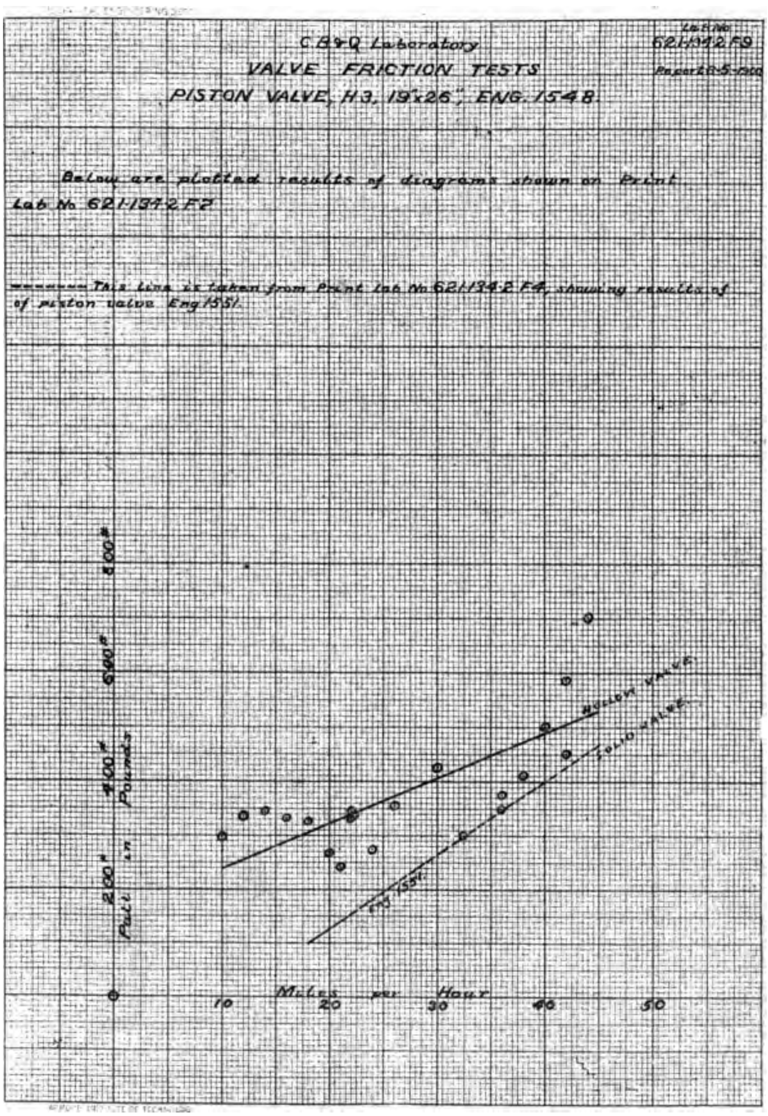
SECTION V.

C. B. & Q. Ry. Tests of Valve Friction.



Section V.

C. B. & Q. Ry. Tests of Valve Friction.



APPENDIX.

SECTION VI.

SECTION VI.

Some Notes on Piston Valves.*

Now that piston valves are attracting so much attention and many locomotives are being equipped with them, it may be of interest to call attention to some peculiarities inherent to certain types, and especially to that of solid design with internal admission.

The following types are to be found on simple engines:

1. The solid form with external admission and internal exhaust.
2. The hollow form with internal admission and external exhaust.
3. The solid form with internal admission and external exhaust.

The first (solid external admission) has very much the same action as the slide valve, but some designers object to it because it requires the live steam passage in the saddle to be divided with a separate branch leading to each end of the valve chamber, thereby bringing the live steam in contact with the more exposed parts of the cylinder with resulting condensation.

The second (hollow internal admission) has the internal admission and exhausts at the ends, but has in addition a hollow center which permits the exhaust at either end to circulate freely and instantly from one end to the other. It is objected to by some designers on the ground that the live steam is jacketed with the cooler exhaust steam in the hollow center of the valve, resulting in condensation.

The third (solid internal admission) also has the internal admission, but is without the hollow center, thereby preventing the exhaust at either end from circulating back and forth except in the roundabout way through the cylinder saddle and back to the opposite end of the valve chamber. This takes some time to do, and, therefore, causes an unequal pressure on the opposite ends of the valve, which is greatest with the following combined conditions: slow speed, full throttle, maximum cut-off, and at the moment exhaust opening occurs.

The extent of this unbalanced pressure does not seem to be generally appreciated.

The following indicator diagrams, however, illustrate the degree of unbalance as well as the suddenness of its occurrence. They were taken from a modern consolidation freight engine equipped with piston valves of the latter type.

Figs. 1, 2, 3 and 4 show the valve and cylinder of this engine.

The diagrams from the cylinder and valve chamber were taken simultaneously with two indicators so that the conditions of steam distribution in the cylinder and exhaust chambers might be known and compared. The indicator connection to the valve chamber is shown in Fig. 5.

*A [illegible] American Locomotive Company, [illegible] September, 1902.

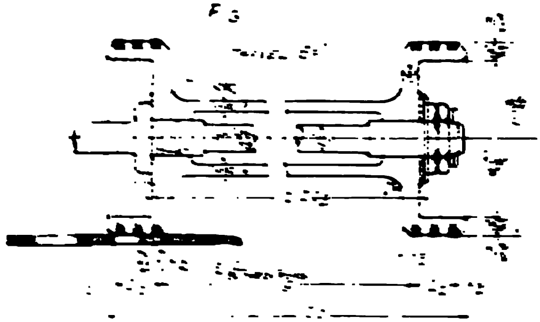
Card No. 6 illustrates the worst condition; it shows a pressure of fifty-four pounds on the end of the valve exhausting, and but 2½ pounds at the opposite end at the same moment. The diameter of the valve being eleven inches and the unbalanced load on one end due to this pressure amounts to 4.960 pounds. The suddenness with which this load is applied is indicated by the almost perpendicular rise shown on the diagram near the ends. The unbalanced load on the end of the valve acts in the same direction in which it is moving, and it takes up all the lost motion in valve gear from the valve to the eccentrics with a sudden shock, the extent of which depends upon the degree of lost motion, but which is apparent on any engine equipped with this form of piston valve.

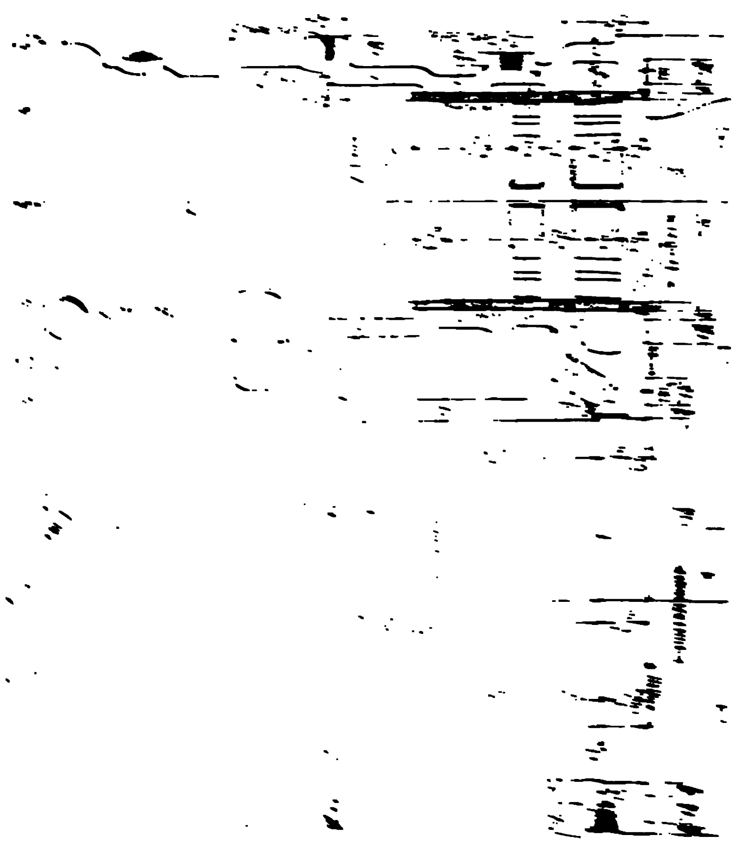
This effect is mentioned by Mr. Delano, of the C. B. & Q. R. R., in the discussion of the Master Mechanics' committee's report on piston valves, June, 1900; but the cause and extent of it does not appear to have been appreciated. It is needless to dwell on the fact that such shocks must be detrimental to the valve gear throughout.

Cards Nos. 7 and 8 were taken at a somewhat faster speed than Nos. 4 and 5, and show how this effect diminishes as the terminal pressure in the cylinder becomes less, due to shorter cut-offs.

The humps near the middle of the exhaust chamber diagrams are due to the rise of pressure in the exhaust pipe occasioned by the exhaust from the other cylinder. They correspond to the similar humps in the exhaust lines of the cylinder cards, and appear to be of greater magnitude than the latter owing to difference in scale of the springs used in the indicators.

Up to the time of writing, diagrams from the other types of valves mentioned are not available, nor are diagrams at higher speeds. It is hoped, however, that at some future meeting the writer will be in position to contribute further data on this interesting subject.





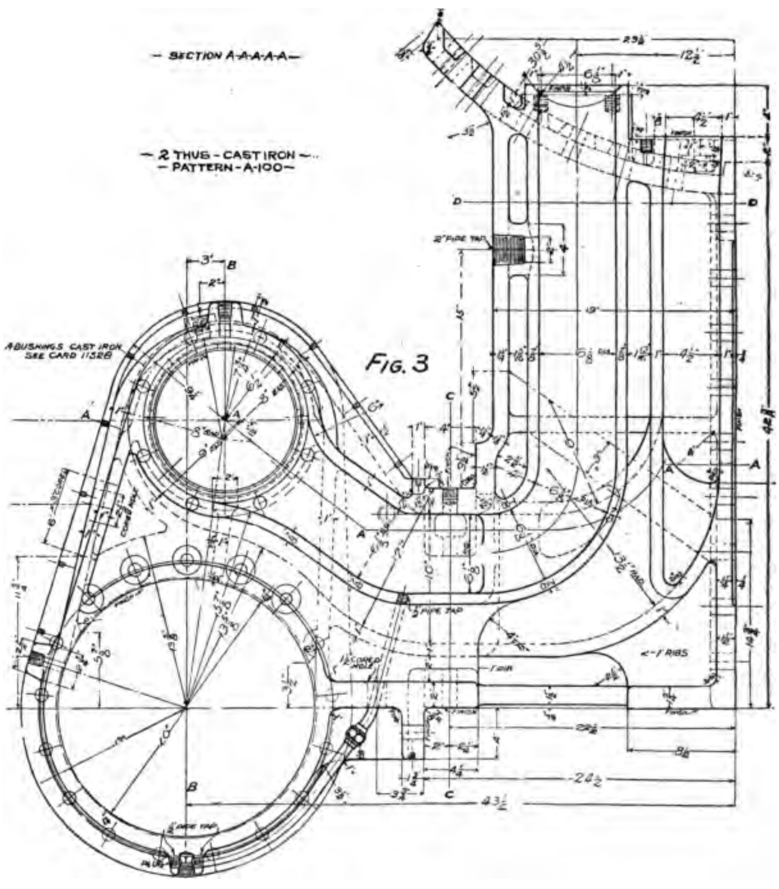

– SECTION A-A-A-A-A –
– 2 THUS – CAST IRON –
– PATTERN – A-100 –
4 BUSHINGS CAST IRON SEE CARD 1132B
2" PIPE TAP
$\frac{3}{4}$" PIPE TAP
1" RIBS

FIG. 3

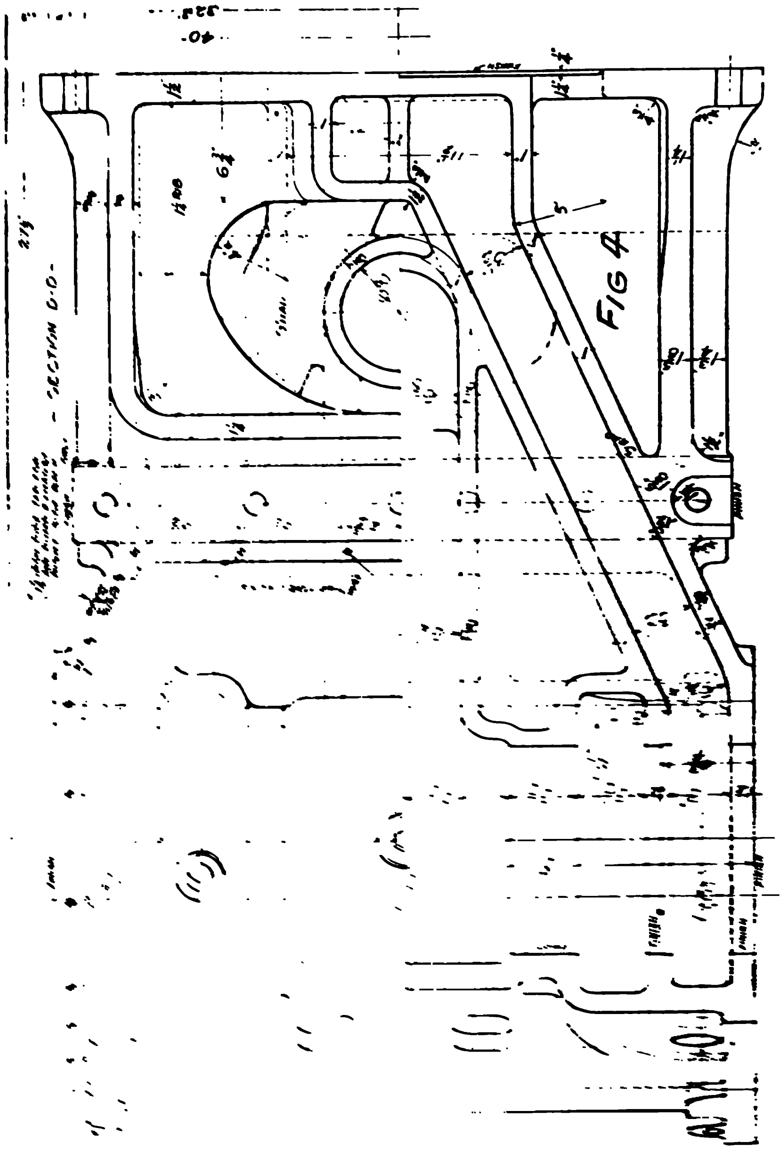


FIG 4
SECTION D-D

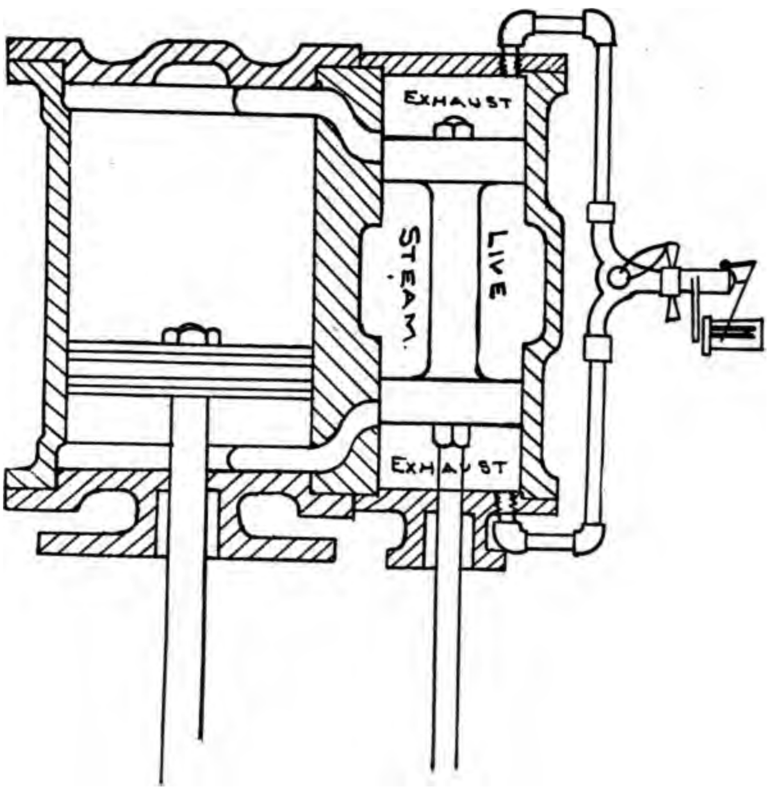
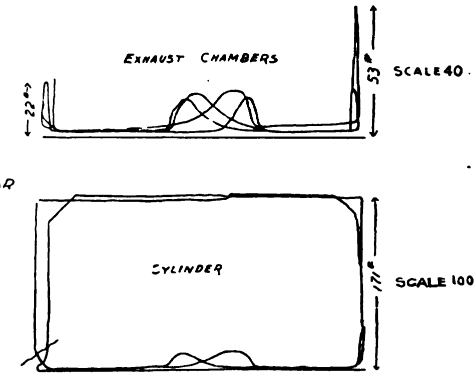


FIG. 5.

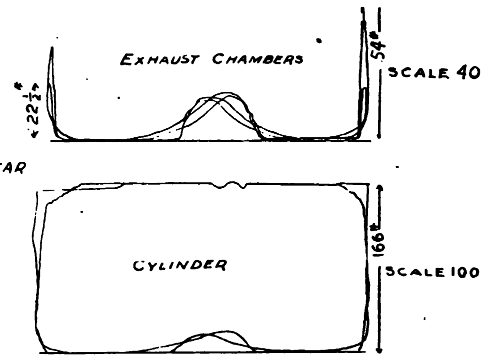
CARD #4.

BOILER PRESSURE 190# .
THROTTLE FULL
REVERSE LEVER FULL GEAR
REVOLUTIONS PER MIN. 21
TERMINAL PRESSURE 145#
MAX. PRESSURE IN EXHAUST CHAMBER } 53#



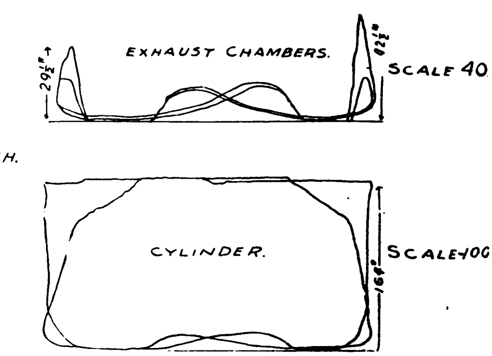
CARD #6

BOILER PRESSURE 185
THROTTLE FULL
REVERSE LEVER FULL GEAR
REVOLUTIONS PER MIN. 33
TERMINAL PRESSURE 145#
MAX. PRESSURE IN EXHAUST CHAMRER } 54#



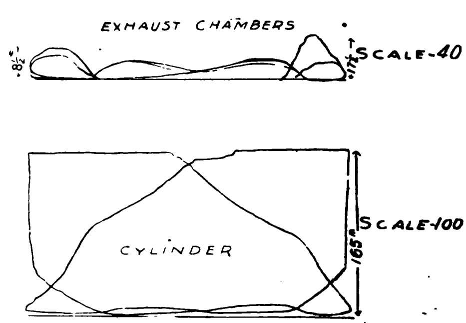
CARD #7.

BOILER PRESSURE 190.#
THROTTLE FULL
REVERSE LEVER 8TH NOTCH.
REVOLUTIONS PER MIN 42
TERMINAL PRESSURE 130#
MAX. PRESSURE IN EXHAUST CHAMBER } 42#



CARD #8.

BOILER PRESSURE 175#
THROTTLE FULL
REVERSE LEVER 14 NOTCH
REVOLUTIONS PER MIN. 60
TERMINAL PRESSURE 80# to 90#
MAX. PRESSURE IN EXHAUST CHAMBER } 17.5#



MR. F. H. CLARK: I am sorry Mr. Gaines, the chairman of the committee is absent, as he had the most to do with this report, and I think he could have presented it in better form than I can. I do not suppose, however, it will be necessary to read the report, time being short and the report long, but perhaps there are a few points I should call attention to.

The committee found that as a general thing the hollow internal admission piston valve was preferred, largely, I think, on acount of the fact that the valve is almost perfectly balanced as regards end thrust, while the solid valve is not. The committee found that relief valves of some kind were used almost universally on cylinder heads, and in some cases by-pass valves also, and that in some instances there was a feeling that the relief valves were not performing the work expected of them. They are usually set a few pounds above the rated steam pressure, and it is said that when needed they are usually found to be out of order. As a result of that, some roads claim to be taking out relief valves and putting in plugs, and with very good results. One road, the Southern Pacific, presented a design for circulating pipes which takes care not only of excess water, but also acts as a by-pass valve, connecting opposite ends of the cylinder when drifting.

As regards the shape of the packing rings, there is quite a difference of opinion. There has been a good deal of difficulty experienced with some designs of L-shaped rings, and there has been a tendency either to drop the L-shape altogether or to shorten up the L extension and increase the section of the ring. Rings made of a somewhat larger section than is generally used and with rather a short extension, appear to be very satisfactory.

The inquiries of the committee with reference to the comparative friction of balanced slide and piston valves indicates as a general thing that the piston valve is more easily operated and the friction is less. Some of the members, we understand, have been experimenting with a type of perfectly balanced slide valve and with very good results. It was the intention of the committee to make comparative tests of these valves as compared with piston valves, but it had no opportunity to do so. One thing that the committee finds to be essential with the piston valve is the use of some form of flexible connection in the valve stem. It

is found that this helps materially to prevent the wear of the valve and bushing.

The principal advantages suggested for the piston valve are the better balance, ease of handling and decrease in wear and tear of motion work. Other claims were made for the piston valve, such as reduced cylinder clearance, better steam distribution, less cost for maintenance, shorter steam passages, decreased back pressure and larger port openings, etc. Some of these advantages seem to have considerable foundation, but in other cases there is some doubt in the minds of the committee as to whether the claims are justified. Among the disadvantages suggested are the difficulty in lubrication, the maintenance of relief valves, broken packing rings, edges of grooves in spool breaking, liability to blow, inability to keep steam-tight and excessive wear on short stroke. One road finds that there is an apparent increased wear in the main driving box with the piston valve. The committee is unable to explain it and so far no explanation has been suggested. It seems to be generally conceded that the wear of the piston valve is somewhat less than that of the slide valve, although there are some who take the opposite ground.

In the matter of bushings, there are conflicting claims — some use the continuous bushing and some the short bushing, some use diagonal bridges and some the straight bridges. The committee is of the opinion, however, that as between diagonal and straight bridges, the straight bridges are preferable, although there may be something in the idea that the diagonal bridges tend to prevent the breakage of rings. The others, however, are less expensive to fit up, and are generally satisfactory.

The committee, as the result of their investigations, recommend as follows:

First. That tests be made by members to determine the amount of loss of steam due to worn packing rings. Such tests should include the various types of rings illustrated in the report.

Second. That tests be made to determine whether the steam or the exhaust rings are the most responsible for the decreased efficiency due to wear.

Third. That the question of proper lubrication of piston valves when drifting be more thoroughly investigated.

Fourth. The attention of the committee being called to the question of valve setting in connection with the piston valve, after it was too late to include it in the circular, by one road stating that with identical valve motions, to obtain equal work, modifications in the piston-valve setting must be made, it is suggested that further investigation be made along this line.

The committee, in making these recommendations, does not feel that it can be of much assistance, and the recommendations are made as suggestions to those using piston valves, and with the idea of calling attention to these points and perhaps promoting investigations along the lines indicated. The committee will ask to be discharged.

THE PRESIDENT: My understanding is that one of the advantages claimed for the piston valve is ease in handling.

MR. CLARK: Yes.

THE PRESIDENT: A paper was read before the Central Railway Club a short time ago by a representative of one of the prominent roads using piston valves. He said that the satisfactory use of these valves depended on conditions — that while the engine was using steam the valve could be reversed, but that it was dangerous to touch the reverse lever while the engine was shut off. I understand that several roads using piston valves are beginning to find broken valve stems, whereas they never experienced any trouble with engines with the slide valve properly balanced.

This paper is now open for general discussion.

MR. ANGUS SINCLAIR: I had considerable experience with the piston valves on marine engines, quite a number of years ago, and the objection to them in marine service was that they could not be prevented from leaking; they always leaked. That was true of valves working vertically. When a piston valve gives trouble from leaking while it is acting vertically, it is liable to give greater trouble when working horizontally. I had no faith in the outcome of the movement toward piston valves for locomotives, and what I have seen and heard since they have become very popular on some roads, has confirmed me in the opinion I formed of them in my marine experience. The piston valve seems to be

much like compound locomotives — a splendid thing, generally speaking, but something must be done to make it perfect. Ever since the compound locomotive has been introduced its friends have said it would be all right if a certain change was made, and when that change is made some other change is suggested. It seems to be the same way with the piston valve. When it starts out and everything goes all right, it does not seem to be leaking badly, although there will be more or less leakage. But when wear does its deteriorating work there is certain to be more trouble than there was with the slide valve. The ordinary slide valve is the simplest arrangement ever introduced for the distribution of steam. It needs no apologies; it does not need enthusiastic friends to keep it in use. So far as I can learn, those who started with piston valves are beginning to find that they are a miserable disappointment. It is fairly good when starting out in good condition, but when it has been used a short time it has all the defects, and more, than have been complained of in the case of the compound. I think the piston valves have come in as a fad and fashion. There has been a strong tendency on a great many railroads to follow fashions. This is not by hundreds the first craze of the kind. This, however, seems to have been an epidemic fashion craze, and the piston valve is likely to be the most expensive piece of novelty chasing that railroad companies have ever been called upon to pay for.

MR. VAN ALSTYNE: Our experience with piston valves leads me to believe that if we had been able to find a slide valve which would give satisfactory service, with the size and pressure required on heavy engines, we possibly might have been better off with the slide valve; but we know we have not had any such slide valve and have had more trouble with slide valves on heavy engines with high pressure than we have had with piston valves. On the other hand, I am inclined to think that piston valves begin to leak pretty soon after going into service, and blow pretty steadily, and the blow increases from then on until the rings are removed. In our case they run about twenty-five thousand miles. I doubt if there is much difference in the cost of maintenance.

As regards coal consumption of engines with piston and slide valves. The only comparison I can make is between two classes

of engines in the same passenger service at the same time, one a 19 by 24 inch eight-wheel engine, weighing 112,500 pounds, and the other 19 by 26 inch, ten-wheel engine, weighing 139,500 pounds. The eight-wheel engine consumed in forty-three months 1.30 tons per ten thousand ton-miles, and the ten-wheel engine 1.60 tons per ten thousand ton-miles in twenty-nine months, or nineteen per cent in favor of the slide-valve engines.

As regards failures of the valves and valve motion, eccentrics and straps, including heating and breakage, comparing the two classes I have just referred to, we had during the years 1901-1902, for the slide valve one failure for ten thousand engine-miles and for the piston valve 17-100, which is six to one in favor of the piston valves. In comparing two other classes of engines, exactly alike except that five of them are simple slide valves, of the American Balance Valve Company's type, and the other five Baldwin compounds, we had four valve-motion failures per ten thousand miles for the simple, and 6-10 for the Baldwin compound, or seven to one in favor of the piston-valve engines. In comparing two classes of consolidation engines, one of which is the cross-compound, having slide valves, and the other is the Baldwin compound, having the usual piston valves, the Baldwin compound had 10-100 of failures per ten thousand engine-miles, and the cross-compound, with the slide valves, had 70-100 failures per ten thousand engine-miles, or seven to one in favor of the Baldwin compound. The same ratio holds throughout with all failures of piston valves, as compared to slide valves, about six or seven to one in favor of the piston valves.

THE PRESIDENT: Were those engines run by the regular crews or chain gangs?

MR. VAN ALSTYNE: Most of the time they were run in pooling service, not in the same service.

THE PRESIDENT: I would like Mr. Minshull to state in regard to the 100-ton locomotives, carrying two hundred pounds of steam, cylinders 22 by 32, how many valves he has faced on those engines.

MR. MINSHULL: We have not faced a valve; we faced two pressure plates, but they were not at all bad. There was a slight wear. The valve seats themselves we have not had to face.

THE PRESIDENT: They have been run by as many engineers as we have on the division.

MR. ADAMS: What did the failures consist of?

MR. VAN ALSTYNE: Everything connected with valve motion, eccentrics, straps, blades, links, rockers, rods and valves. The figures include failures from breakages and heating.

MR. W. G. WALLACE: I would say a word in regard to the piston valve. We, as traveling engineers, are in favor of them. One reason is on account of the ease with which the engine can be handled; also the men feel that they can get lubrication to the valve seats or bushing when they become dry easier than they can with the slide valve. So far as the repairs are concerned, it has reduced our repairs to valve seats very much. The engines that we have equipped with piston valves are larger engines than those formerly run with the balanced valve, but we have very little trouble with the piston valve and I think have only removed one bushing in a year and a half, and occasionally a broken ring, but possibly not more than one in six months. The reason, I should judge, for the valve rods breaking and the complaint of not being able to drop the lever when the engine is shut off, is due to the fact that you have a heavy valve moving at a high speed, and when the engine is shut off and the lever is put forward, you put nearly all that work on the forward-motion eccentric, and you get the full travel of the valve. You have a valve that weighs 150 pounds or upward, with a transmission bar that will weigh another 125 pounds, and the continued full travel and quick reversal at a high speed is what is causing the trouble from broken rods. That will also cause excessive wear to eccentric rods and rocker boxes, but we try to have our men, when they shut off an engine at high speed, either piston or slide valves, leave the reverse lever near the running cut-off until the speed has been reduced. That, I think, is one reason for the piston valve giving so much trouble. It being so much heavier than the slide valve, and putting the lever in the full forward gear would have a tendency to produce excessive wear and perhaps break the rods.

MR. JOHN PLAYER: I wish to say a few words in connection with piston valves, as I have probably had as much to do with

them as any one. One of the first questions brought up in the paper was relative to the use of the hollow or solid piston valve. The report states that the preference seems to be for the hollow valve, that is, with the exhaust cavity passing entirely through the valve. The original piston valves which we constructed, and which other roads have also applied, had the hollow cavity for the exhaust, with the supposition of producing an entirely balanced valve. We found, however, with that valve after the period of commencement of exhaust, the exhaust pressure had a tendency to accelerate the motion of the valve, or in other words increase the pressure against the exhaust packing ring. There was an objection at that time, chiefly raised by engineers, to the sound of the exhaust of the piston valve, that it was muffled: it was, in comparison to the exhaust of a slide valve. We also found that the exhaust was not quite as sharp from the piston-valve engine, although you could run with a small sized nozzle the same size as with slide-valve engines, yet the exhaust did not sound as sharp and there was a tendency to close up the exhaust tips to produce the sound. To overcome that we made the ends of the valve followers solid, and built a great number of engines with the ordinary two-opening exhaust, with both cavities opening into the same chamber, same as a slide valve. We found that the acceleration of the valve at the period of commencement of exhaust was practically not increased to any appreciable extent by making the ends solid. Shortly after that we introduced a further betterment in the adoption of a four-opening exhaust; that was by making the two exhaust cavities in the cylinder entirely separate, and carrying them upward in the exhaust pipe, and making the exhaust pipe with four openings at the base, and carrying two a portion of the way up and the other two a portion higher. The proportions of the exhaust pipe above that being approximately the same as those recommended by this Association. We found by the adoption of the exhaust cavity and pipe we were able to enlarge the nozzles on an identically similar engine, enlarging the exhaust tip anywhere from 3-16 to 3/8 of an inch, showing the benefit of the solid-end valve with the separate exhaust. The objection that has been raised that there was an exhaust pressure on the ends of the valve, does not hold in this case. For one thing, we get a larger opening at the exhaust tip

which relieves the back pressure. The indicator cards show the back pressure is lower than that in any slide-valve engine which can be built. There has been some trouble with relief valves on the cylinder heads. Relief valves with piston valves are a necessity on cylinder heads, especially at high speeds. In some places they screw them down instead of adjusting them at proper pressure, and consequently they do not work. They should be made so that they can not be monkeyed with. As to the by-pass valve, it is beginning to be an appreciated fact that by-pass valves combined with piston valves are a benefit, especially upon engines that have to do drifting. Some of the former patterns of by-pass valves that were applied to piston-valve engines were not altogether a success. The areas were insufficient, in the first place, and the construction of the valve was such that they had a tendency to stick once in a while, and sufficient attention was not paid to them to keep them in order. All that trouble has been eliminated in the improved form, and they are a necessity upon passenger and freight engines that do much drifting.

With relation to circulation pipes, they perform practically the same function as the by-pass valve, but have a tendency to freeze up which is not a desirable feature. The results accomplished by the circulation pipe can be accomplished by a good construction of by-pass valve. As to the packing rings, reference has been made to the abandonment or substitution of some other form for the L-shaped ring. Some of them were made entirely too light in section, and the projection over the follower was entirely disproportionate to the section of the ring itself, in some of the early forms. Any properly proportioned L-shaped ring is the ring to use, as it gives you a proper cut-off edge. One objection to using these in solid valves has been there is some trouble in springing them over, so that you start an initial strain in the metal which causes breakage afterward, but with the follower we have there is practically no breakage in the L-shaped rings if the valves are properly lubricated. The friction of the valves has been treated on, and it is undoubtedly considerably less than obtainable for any slide valve. Regarding the valve-stem connections, they should be made flexible where practicable. The valve, in my judgment, should be supported by the stems at both ends in bushings so as to relieve the weight of the valve on the bushing itself. I

have seen valves supported at both ends that ran two years and a half, where the tool marks were scarcely worn off the bottom of the valve.

The advantages in handling the valves have been treated on by previous speakers. The cylinder clearance of large engines with slide valves is something abnormal, in many cases. The clearance obtainable with piston-valve cylinders varies from six to eight per cent in a simple engine, although contrary statements have been made. I do not know of any piston-valve engine of recent design where the clearance exceeds nine per cent. The disadvantage of breaking of packing rings is a local matter; it is due to insufficient lubricating or a fault in the proportion of the ring itself. If proper followers are used and the rings are of proper shape, that will disappear. The wear of the packing rings is also largely due to the proportion of the rings. The wear of the driving box on one road mentioned in the report I believe was due to the absence of by-pass valve with the proportion of the cylinder used. I think if a by-pass valve were applied on that cylinder the trouble would disappear.

With regard to bushings, the bushings made with bridges slightly tapered have accomplished the same results as angular bridges and are as easy of construction as the ordinary bushing. The lubrication of the piston valves is an easy matter. In some forms the lubrication is applied at both ends of the valve, instead of in the center, with very marked benefit.

In regard to Mr. Sinclair's reference to marine valves and the leakage of them, I understand that reference to be to low-pressure engines. If they had so much trouble with piston valves in marine service years ago, why is it that the British government, the United States government, and all these large transatlantic steamer lines are using piston valves? If the slide valve is better why do not they use it?

With regard to the trouble that has been mentioned in handling piston valves, as to the dropping down in the corner, and the racking of the valve motion occasioned by it, proper instructions should be issued to engineers for the proper handling of piston-valve engines to the effect that, as the last speaker suggested, the lever should not be dropped down while the engine is speeding, but dropped down gradually as the speed decreases, as

you are going into a station. The object of this is obvious. The piston valve runs in a bushing, and not over a plain surface like the slide valve. The lubrication for the bushing and valve is taken in the middle, and the lubricated surface is that over which the packing ring travels. The surface covered by the exhaust steam, which is not covered by the travel of the valve when working, becomes dry and encrusted to a certain extent with the scum which you usually find in a steam chest. When you drop the lever in full gear, you have to cut that all off at one stroke, practically speaking, or else it snaps in the packing rings and the packing rings travel over it, and the fact of always dropping the lever down at speed is one of the most serious objections in the use of piston valves. It causes practically all the trouble of breakage of packing rings and the failures of the valve motion referred to. If the valve is handled in a proper manner, not dropped down when run at speed, but as you slow down drop it down gradually, there will be no trouble experienced with the piston-valve cylinder.

MR. WILLIAM MCINTOSH: The road with which I am connected (Central Railroad of New Jersey) has many piston-valve engines, and while we do not claim they are perfect, we do claim we get good results, and in my judgment the results are equally as good as we could expect to obtain from slide-valve engines, if not better. It would be inferred from some of the remarks which have been made that a slide valve never gives any trouble, either in the way of leaking or failing in other ways. My experience in operating and caring for slide-valve engines is that they do give us lots of trouble, both in the way of leaking joints and quite largely in the way of difficulty in maintaining the steam chest to keep them tight. There is a great deal more trouble and expense in keeping up the ordinary slide-valve chest than in maintaining the cylindrical or piston-valve chest.

So far as renewing the bushing is concerned and breaking rings, there is very little trouble experienced with our engines in that respect. I presume they leak some, but they have been doing good business right along, and we have not had the time to go into the little refinements of hunting for small leaks. They are handling good trains and have been on the road every day. Some of our high-speed engines have broken the connecting parts, but we have found in nearly every instance it was due to poor metal.

We have quite a number of cast steel parts, and you know there is considerable difficulty in securing good castings. In fact, on every class of engine equipped with wrought iron parts, we have had some breakages also, but usually from the same cause.

MR. E. W. PRATT: In Mr. Clark's closure of this paper, I would ask him to tell us if the committee, in stating that the port opening is greater with the piston valve than with the slide valve, found this to be proven by means of the indicator. Can you take the annular openings of the rings from the bridges as the actual port opening, or must you take the cross section of the steam-chest core in comparison with the opening of slide valves, either Allen or plain?

MR. F. H. CLARK: I will say in reference to that, I do not know how the calculations are made that are given in this paper, but I presume that the annular length of the port was considered. I think it is generally the idea, in designing cylinders, to so arrange the cores that the area of the ports will be about equivalent to that of the openings to the bushings.

MR. DAVID BROWN: You have heard the good qualities of the piston valve, and I am informed there has been an improvement on them lately that has been quite a benefit. What the improvement is I could not say, but unfortunately we have those that are not improved. The question was asked about the length of the port. If we take the whole periphery of the circle, we will have a good long port, but the annular space back of the edge of the port is not the same all the way around. For instance, on the top it is very much contracted, and there is very little space from the edge of the bushing to the top of the annular space. Consequently, any steam that goes in there has to be forced through the bridge on each side of it and still further on it is contracted, so that you do not get the benefit of the port you think you have. Another feature about it is that it does not give a chance to fasten the cylinders to the frame as we can in the other valve. There have been so many additional parts put on, which some of the speakers have mentioned, that I do not think are a good feature; for the sake of maintaining the piston valve, you have to crowd on four or five other equipments, and the more we put

on, the more trouble from failures, like having another baby in the family that wants looking after.

As to the packing rings, some are in favor of having them stronger and others lighter. My opinion of the ring is, it is too heavy and not elastic enough; you get it only a size larger than the bushing, and when that is worn away the ring is loose in the bushing and you have to depend on the steam to open it. If the ring was not so heavy it would expand more when the steam got under it, between that and the piston, and send it out easily. We have a great deal of trouble with valves blowing, on that account. They are hard to adjust; it takes a good man to adjust them. If you take anything off the face of the piston to let the packing in further, you change your lead lap and exhaust clearance unless guarded. One gentleman remarked about dropping the lever. I do not think an engineer will drop it more than once. If he does, he learns by experience that not only the lever goes down, but he also goes out of the cab door. Mr. McIntosh spoke about the material. We had engines with piston valves which we expected to put in high-speed service, but they frequently broke the eccentric rod, or sheared off the bolts in the blade. We took them off the fast trains and put them in slower service where they are now doing better. There is another thing I like about high-speed engines, not necessarily on freight, but I think the Allen port is a very good addition to high-speed engines, and if we could get a second exhaust port, double exhaust, I believe we would have a much better valve than anything we have used yet. We have had three steam chests break, and it is pretty expensive to throw away cylinders and steam chests to replace a bursted steam chest, which is another feature in using piston valves.

Mr. Clark: I have nothing in particular to say in closing this discussion, as most of the criticisms made have been answered by others, and some of them, I suppose, will have to remain unanswered. We all know there are objections to the piston valve.

Mr. Van Alstyne: I move that the recommendations of the committee be referred to the Executive Committee.

Mr. Forsyth: Mr. Clark, did you propose to have the recommendations carried out?

THE PRESIDENT: The motion was to refer the matter to the Executive Committee.

MR. FORSYTH: What will they do with it?

THE PRESIDENT: They will determine what is best to be done with the subject.

MR. FORSYTH: My idea was to continue the committee to carry out its own recommendations.

THE SECRETARY: The motion was to refer this subject back to the Executive Committee, and in its preparation of the program for next year the Executive Committee would determine what committee should consider it, whether the old one should be reappointed or a new committee be appointed.

Mr. Van Alstyne's motion was carried.

THE PRESIDENT: We have now exhausted our regular order of business and as we have fifteen minutes of the noon-hour left, we might take up one of the noon-hour topics. The first in order is on "The Steam Turbine." This will be opened by Mr. L. R. Pomeroy.

MR. POMEROY:

THE STEAM TURBINE.

More interest has probably been manifested by steam users in turbine development, than in any single subject of a mechanical nature which has come up in steam circles during the last twenty years, or since the application of steam power to electrical generation has been an accomplished fact. And by many experienced steam engineers it is believed that the turbine will accomplish a revolution in the methods of generating electric power for all purposes.

Dr. Thurston has aptly and pithily characterized the steam turbine as follows:

"The steam turbine is characterized as the steam engine of maximum simplicity and of ideal thermal efficiency.

"The steam turbine is in essence economical through its simplicity and the directness which distinguishes its method of thermodynamic energy conversion.

"Another characteristic is the very small loss of mechanical efficiency through friction of journals, and also the further fact that there is no variation in angular velocity, as in the reciprocating engine. The steam turbine is entirely free from the great source of waste in the reciprocating engine, i. e., that internal variation of temperature of metal surfaces which, ranging from the temperature of prime steam to that of the exhaust,

nearly produces wastes amounting to from ten per cent to sometimes fifty per cent and more of the heat, steam and fuel supplied.

"In ordinary reciprocating engines, the cylinder walls and pistons are exposed alternately to the initial and exhaust temperature, causing partial condensation at each charge of incoming steam. This difference increases with increase of temperature limits

"On the contrary, the parts of the turbine in contact with the steam are not subject to any cyclical variations in temperature.

"In the turbine, the most important loss, which is inseparable from the reciprocating engine, is entirely eliminated; and there is apparently no reason why there should be any practical limit to initial pressure or expansion.

"The mechanical friction of the turbine is particularly small, and the work spent on friction is not naturally increased by increasing the range of expansion. This allows the steam to be properly expanded much further than would be useful or even practical in the ordinary reciprocating engine. In the reciprocating engine, there are innumerable tight-fitting joints causing internal friction. There is also the necessity of much fitting, so many fine adjustments and valve settings, all of which must be done with great care, precision and patience.

"All forms and types of turbines, regardless of detail, depend for action upon principles that may be simply stated and easily understood. In the steam engine, the heat, or molecular energy of the steam, is manifested mechanically as pressure, and is transformed directly into the movement of the piston of the engine. In the steam turbine, the molecular energy of the steam is transformed first into the energy of a stream of vapor moving in answer to a pronounced fall of pressure, and in which a high velocity of translation is thus developed. The energy of this moving stream is then transformed into mechanical motion through impact on moving vanes, as a consequence of which a part of the energy is transferred from the stream to the vanes. All forms and types of turbines, no matter what the detail, must be adapted to absorb, in this general manner, the energy of the stream. In the development of types, two broad lines have been followed. In one the purpose has been to transform, as completely as possible, and in one operation, the heat energy of the steam into the mechanical energy of the escaping jet. This then impinges on the vanes of the turbine and gives up such a fraction of its kinetic energy as the conditions may determine. The De Laval turbine is a representative of this class. In the other general types, the two transformations are more or less continuous or distributed in stages throughout the machine. Thus the heat energy is partly transformed by expansion into the energy of the jet, and this into mechanical energy through action on the vanes. Then the same process is repeated until the largest possible fraction of energy has been thus transformed. In some cases the two transformations are in a measure carried on side by side, the heat energy being transformed by expansion into mechanical energy in the jet, and then through action on

the vanes into the motion of the turbine. The Curtis, Parsons and Rateau turbines are all of this general type, though differing in the general manner in which they fulfill the fundamental principles above referred to."

A gaseous fluid, such as steam, in passing from a receiver at one pressure into a receiver at another pressure, acquires a definite velocity, due to the difference in pressure. For example: steam at 150 pounds pressure expanding into the atmosphere is capable of imparting to itself a velocity of about 2,950 feet per second, and if expanded into a vacuum of twenty-eight inches, will attain a velocity of about four thousand feet per second. A jet striking a surface will exert a definite pressure against that surface, the value of which, in the case of normal impact, is expressed by half the square of the velocity per second into the mass of the fluid delivered against the surface per second. Should a surface, against which such a jet impinges, such as that of a vane attached radially to a shaft, remain fixed, there will, of course, be no energy delivered to the shaft; it is also evident that should the vane have the same velocity as the impinging jet, no energy will be delivered, since there is no exchange of velocity between the jet and the vane. The maximum amount of energy delivered will be when the vane has about one-half the velocity of the jet, for in that case the remaining velocity in the jet after impact will equal the velocity of the vane, and therefore be incapable of imparting further energy. Speaking broadly, in order that a single wheel steam turbine may act at maximum efficiency, its vanes should have a velocity of about two thousand feet per second working between the foregoing limits of pressure, that is, not far from the velocity of a projectile from a modern piece of ordnance. The spouting velocity of water discharged from a nozzle with a one hundred feet head is eighty feet per second. These figures illustrate the radial difference or conditions between water turbines and steam turbines. On account of the lower velocity of the water jet, it is possible to approach the speed of revolution in the water turbine correspondingly with the theoretical maximum economy. The elasticity of steam, however, as contrasted with the non-elastic condition of water, compels the compounding of the steam turbine, as the compounding of the water turbine would destroy its efficiency, while the momentum of the steam, though checked by the first series of buckets, recovers itself instantly by expansion, and is checked again and again by successive series of buckets, until the steam has expended its expansive force. It is thus readily seen that the problem encountered in the steam turbine is to extract from the steam the work due to its velocity without exceeding a moderate rate of revolution of the shaft carrying the vanes upon which the steam expends its velocity.

In the Curtis turbine the reduction of speed is obtained: First, by placing the vanes upon which the steam impinges at a relatively great radial distance from the axis of revolution, since for a given speed of peripheral velocity, the revolutions will be inversely as the radius. Second, by a gradual absorption of the velocity of the steam at the periphery of a

number of vane wheels; and instead of having all of these wheels in one chamber, they are divided into two or more groups of three or more wheels, contained in separate chambers, but secured to the same shaft. This provides for the development and partial absorption of velocity in stages, the work being equally divided among the several stages.

The De Laval turbine depends almost entirely on an initial velocity due to complete expansion of the steam in the nozzle, while with the Parsons, being of the parallel flow type, the energy imparted to the vanes is that due to the expanding steam through the wheel. In the Curtis, advantage is taken of any initial velocity due to the amount of expansion in the nozzle, availed of, coupled with the additional velocity as the result of expansion through the turbine. Velocity is imparted to the steam in the expanding nozzle so designed as to efficiently convert nearly all the expansive force, between the pressure limits used, into velocity of the steam itself. After leaving the nozzle, the steam passes successively through two or more lines of vanes on the moving element, which are placed alternately with reversed vanes on the stationary element. In passing successively through these moving and stationary elements, the velocity acquired in the nozzle is fractionally abstracted, and largely given up to the moving element. Thus the steam is first thrown against the first set of vanes of the moving element, and then rebounds alternately from moving to stationary vanes until it is brought nearly to rest. By this means a high steam velocity is made to efficiently impart motion to a comparatively slowly moving element. The nozzle is generally made up of many sections adjacent to each other, so that the steam passes to the wheels in a broad belt when all nozzle sections are in flow.

In steam consumption several of the present commercial forms of steam turbines show economic performances somewhat less than those of the most efficient reciprocating steam engine, such as is designed for pumping service, though apparently fully equal to the best types of reciprocating engine used in electrical generation and superior to the ordinary engines employed in that service. A specific advantage claimed, however, is that there is very much less falling off in economy at fractional loads as compared with the best type of reciprocating engine, which, it is perhaps unnecessary to add, is a point of the highest importance in electrical generation. Moreover, there are the undisputed commercial advantages of considerably less cost of turbo-generator unit and less floor space occupied. Moreover, the possibility of using a very high degree of superheat with the turbine still further extends its possible economic advantages over the reciprocating steam engine. A 600 kw. unit showed an economy of nineteen pounds of dry steam per kw. hour full load; and 20½ pounds at half load; this is the equivalent of 12½ pounds per I. H. P. hour full load, and 13½ pounds at half load; and with 150 degrees superheat, 16.75 pounds per kw. full load and 17.8 pounds at half load, or the equivalent of 11 pounds per I. H. P. at full load and 11.7 pounds at half load.

A very interesting fact concerning the development of the steam turbine is that large and small turbines are nearly equally efficient.

"The turbine makes a strong appeal to the business man or the engineer, on the ground of its inherent commercial efficiency. By this I mean that its efficiency is unchanged week in and week out, year in and year out. Leaky pistons or valves, lack of alignment of slides and bearings, keying up, and above all, lubrications, all of which exist in the reciprocating engine, are eliminated in the turbine." (F. A. Waldron.)

The steam turbine lends itself directly to solutions of problems involving the necessity of concentrating the largest amount of power in the smallest possible area consistent with economic operations.

Some of the advantages are:

1. High steam economy — full load economy being substantially the same as the overload economy, thus permitting of a very large overload capacity, and the fractional load economy being but little inferior to that of the full load.
2. Extreme mechanical simplicity — there being no packing at all except a single shaft packing on the top of the turbine which is required to hold only one or two pounds pressure, the bearings have no weight and the wear on the parts will be substantially nothing.
3. Extremely small floor space — in the larger sizes about .02 square feet per kw. of rated capacity.
4. Perfect symmetry of form.
5. Uniformity of expansion with no alignment difficulties.
6. Ideal form and speed of generator.
7. Accessibility of all parts.

To sum up: If, then, we can offer a prime mover for the generation of electricity, that is more simple than the complex piston engine, the cost of maintenance of which will be less on account of this simplicity, that is more economical of operation and of space occupied, and withal, that is cheaper, it would seem that the subject of steam turbines ought to interest nearly every steam user.

THE PRESIDENT: The subject is now open for discussion.

PROFESSOR HIBBARD: I just wish to add one word of interest to those who want to follow the progress of the art along the turbine idea. There appears to be great possibilities for the gas turbine. A gentleman connected with one of our western universities has just taken his doctor's degree on a very thorough investigation of the gas turbine, with the result that the General Electric Company has taken him away from that institution and retained him in its service, giving him, I presume, unlimited facilities, that mean much for the investigation and improvement of the gas turbine; the patents, of course, to belong to the Gen-

eral Electric Company. That would seem to be along the line of the steam turbine, and perhaps also along the line of Mr. Sanderson's paper on "Internal Combustion Engines for Railroad Service."

On motion the discussion was closed.

Of the topical discussions not reached during the convention the following were handed to the Secretary for incorporation in the Proceedings: "Is it necessary to use two 9½-inch pumps, or one 11-inch pump on freight locomotives." To be opened by Mr. A. E. Mitchell.

Mr. Mitchell:

This question, under certain conditions, can be answered in the affirmative and under other conditions should be answered directly to the contrary.

For divisions, other than mountain, where the grades are low, the application of brakes infrequent, and the safety of the train not jeopardized if the train line and auxiliary reservoirs are not instantly recharged, one 9½-inch air pump will, without doubt, give very good and satisfactory service, especially if a yard testing plant charges the train line and auxiliary reservoirs at the point where the train is made up. If the 9½-inch pump is required to charge and maintain the train line and auxiliary reservoir pressure on trains of sixty to eighty cars in length, much valuable time is lost in charging the train which could be utilized to better advantage on the road, besides the work required from the pump is very heavy. Under such conditions I believe two 9½-inch pumps or one 11-inch pump would prove to be an economical proposition, not alone in the time saved but also in the freedom from pump failures, due to overheated discharge valves, worn-out piston packing rings or dry air cylinder, and in reducing very materially the cost of making repairs to the pumps.

For our heavy freight power operating over mountain divisions with long and heavy grades, two 9½-inch pumps, or one 11-inch pump appear necessary, or at least advisable. The safety of the train demands that the operation and efficiency of the brakes must be as near perfect as it is possible to have them; they must not fail during the period of time occupied in making the descent or the results may be disastrous, hence, anything that tends to reduce the liability of failure should be introduced if by so doing economy in train operation or reduction in train casualties is obtained, and the introduction of two pumps in place of one reduces the liability of pump failures nearly one hundred per cent, to say nothing about the enormous advantage in maintaining main reservoir pressure and being able to recharge the train line and auxiliary reservoirs much more rapidly than would obtain with only one pump.

Our experience with two 9½-inch air pumps in mountain service has

fully demonstrated the wisdom of their introduction and have very materially increased the safety of operating trains over the very heavy and long grades which obtain on the Rocky and Cascade mountain divisions of this road.

We also find that our pump failures and delay to trains incident thereto are practically eliminated, the time service obtained from each pump is materially increased and the cost of repairs to pumps no greater. Considering the question as a whole, I am of the opinion that the railroads can not receive any quicker returns for the small amount of money invested in a 9½-inch pump with its governor, than to introduce it on this heavy power regardless of whether such power is engaged on mountain or level divisions.

I further advocate the introduction of two 9½-inch pumps instead of one 11-inch pump on the same principle that two injectors are used on each locomotive, namely, to obtain the service of one should the other one fail. Both, however, should be operated at the same time in order to reduce the duty required from each, and thereby obtain the reduced cost of repairs which would result. On light and medium power one pump is sufficient if properly maintained.

"Water Purification — Results Accomplished." To be opened by Mr. W. R. McKeen, Jr.

MR. MCKEEN:

Under the subjects "Recent Improvements in Boiler Design," "Long Locomotive Flues," "Most Satisfactory Way of Setting Flues" and the discussions following same, the facts show that the modern high-pressure locomotive boiler gives considerable trouble in one way or another. From the remarks of Mr. Humphrey we note boilers of like design and capacity give no trouble at all in certain localities, whereas in other localities they are a constant source of trouble. I believe this last observation shows conclusively that the best method of correcting locomotive boiler troubles is to be found in correcting the trouble with the water used. The Union Pacific railroad has started in on this basis: i. e., to remedy locomotive boiler shortcomings and improve service means simply improve the water supplied to locomotives. We have attacked this proposition in several ways:

1. By means of pipe lines and water cars distribute from a known good water supply to as many neighboring water stations as is practicable.

2. By means of new wells and explorations search territory for new and good water supply; or by means of reservoirs store snow and rain water in wet season sufficient to tide over dry season.

3. Treat all waters furnished locomotives, reducing incrusting solids to a minimum, and bring all water to a uniform constituency as far as is practicable.

We have already obtained some very striking results on the Union Pacific. The middle district of our mountain division was well known

for its bad water, full of acids, alkaloids and incrusting solids; sulphates causing engines to foam, leak, etc. Water on west end was full of alkali. Water in middle territory was very high in incrusting solids and foaming qualities. Water on east end was full of incrusting solids and free acids; "old-timers" state that this water would "burn a hole in a blanket."

By water-pipe line the east end situation was rectified. The middle territory water was treated and redistributed. West end water was distributed, making same uniform.

FORMER SITUATION — WORST WATER DISTRICT ON SYSTEM:

Life of flues was from three to six months. From time engines left shop boilermaker work was necessary every twenty-four hours. Engines leaking between terminals caused no end of trouble and expense.

RESULTS OBTAINED NOW — BEST WATER DISTRICT ON SYSTEM.

Life of flues from eighteen to twenty-four months. Have four compound engines, which have been in service two years, handling 13,500 tons as a rating; boilers and flues have not given any trouble whatever. Engines have just been thoroughly overhauled, with the exception that flues were not changed. We expect these engines will give at least twelve months further service before it will be necessary to change flues. Passenger engines, compounds, have made as high as 148,000 miles between shoppings; engines finally shopped account of worn-out condition of machinery. None of the compound passenger engines are making less than 135,000 miles between shoppings. We have in operation at the present time eleven water-treating plants, with a capacity of 122,000 gallons per hour. By the first of January next we expect to have twenty-five additional plants in operation, with a capacity of 285,000 gallons per hour, making a total capacity of 407,000 gallons per hour.

In conclusion I may state, we have used soda ash, tri-sodium phosphate and other chemicals in locomotive tender cisterns and obtained some very fair results, but the only reliable, practicable and satisfactory method of purifying water is to treat same in tanks or reservoirs, removing the undesirable ingredients *before* water is pumped into water-station tank. Our present system of checking and inspecting the boilerwork, boiler-washing and care of boilers, as performed by each roundhouse, and in connection with the water question, is also productive of very good results.

THE PRESIDENT: We will now receive the report of the Committee on Subjects.

Mr. G. M. Basford read the following report:

REPORT OF COMMITTEE ON SUBJECTS.

To the members of the American Railway Master Mechanics' Association:

In view of the large number of new problems, and old ones in new form, which are now being offered to mechanical officers for solution, your committee finds it difficult to keep down the number of subjects. It has

suggested thirteen subjects for committees and seven for papers with the expectation that the Executive Committee will select a practical number.

In this selection an effort has been made to eliminate questions which may be more profitably dealt with in local organizations in favor of those which appear to involve fundamental principles and which, therefore, affect the practice of the motive power department, irrespective of local conditions.

The most careful attention of the members to the importance of the selection of subjects is earnestly recommended.

FOR INVESTIGATION BY COMMITTEE.

First: A standard or formula for use in comparing locomotives, with reference to steaming capacity. An investigation of the various methods of comparison suggested before this association and in the technical press and a definite recommendation which may be used in the design of locomotives.

Second: Electrical equipment of shops and shop powerhouses. What do the manufacturers need to consider to more fully and satisfactorily meet the special requirements of railroads as to electrical machinery?

Third: Boiler tubes. What is the reason for the apparent increase of difficulties with leakage in the tubes of large locomotives? Is the present tendency toward crowding boilers full of tubes in order to secure large heating surfaces a good one? Should not more space be provided between tubes for the improvement of circulation — especially in bad water districts? What is the cause and what the remedy for leaky tubes?

Fourth: Coal consumption on locomotives. As affected by enginemen, by the size of boilers, by the size of grates and the loss of time on side tracks. Are large grates disadvantageous because of the stand-by losses due to long waits on side tracks? Have recent locomotives with large heating surfaces and large grates, carrying a relatively large proportion of their weights on trucks and trailers, met expectations from the fuel standpoint? If not, is the "large locomotive" justified from the operating standpoint?

Fifth: What is the proper location of water glasses and gauge cocks in relation to the crown sheet and the center line of the boiler? What is the proper slope of crown sheets, expressed in inches per foot of length? Is an automatic low-water detector a desirable attachment for general use on locomotives?

Sixth: Automatic stokers for locomotives. Has past experience led to the hope that they may be made satisfactory for general service?

Seventh: Machine tools. What do the manufacturers need to consider in order to more fully meet the requirements of railroad shops?

Eighth: Grates for bituminous coal. What is the best practice to meet various conditions as found in different sections of the country? The subject of grates for anthracite coal was presented to the association in 1897.

It is suggested that the same kind of investigation should be made with reference to grates for soft coal.

Ninth: Locomotive frames. The question of design for large locomotives is suggested, with reference to a study of the causes of breakage. How shall the distortions, both vertical and horizontal, be provided for and which deflection is it most necessary to provide for or prevent? Which is the better material, cast steel or wrought iron?

Tenth: Cost of locomotive repair shops. Power plant — cost per horse-power, separating boilers, engines, generators, buildings, coal and ash handling facilities, piping, switchboard. Locomotive shops — cost per cubic foot and cost of machinery on the basis of horse-power of tools, with tool list. Countershafting — relative cost of direct driving as compared with countershafting. Piping — cost of air, water and steam. This subject should be treated so as to put shop estimates on an intelligent basis for use in designing new shops.

Eleventh: Rapid destruction of side sheets in wide fire boxes and the reasons for it.

Twelfth: Best form of radial stays.

Thirteenth: Fire-box steel specifications, including the thickness and spacing of stay bolts.

SUBJECTS FOR INDIVIDUAL PAPERS.

A. What can be done to retain bright and promising technical-school graduates in railroad service after the completion of special apprenticeship.

B. Organization of the motive power department. Is the ordinary organization now prevailing adequate to cope with the requirements of the times? If not, where is the weakness?

C. Recent progress in the use of oil fuel in locomotive service. What constitutes successful practice?

D. Terminals for locomotives — how may methods for rapidly caring for locomotives at roundhouses be improved? What are the weak spots in roundhouse operation and what is the ideal roundhouse organization? Is it the "big engine" or the roundhouse that has failed?

E. Improved tool steels — what have they done for railroad shop output? What is the relation between tool steel, motor driving and machine tools?

F. By-pass valves for piston-valve engines. Can a piston valve be operated successfully without them? If not what are the elements essential to a satisfactory by-pass valve?

G. Motor driving for locomotive shops. What are the essential principles of successful systems? What are the possibilities and the limitations of variable speeds in railroad shop practice? All things considered, what is the most satisfactory system for railroad shops, as developed in actual practice?

SUBJECTS FOR TOPICAL DISCUSSIONS FOR CONVENTION OF JUNE, 1903.

The committee suggests a larger number of subjects than can be discussed, in view of the possibility of the unavoidable absence of some of the members selected to present them.

TOPICAL DISCUSSIONS.

1. Long locomotive flues — experience to show whether or not they give more trouble than short ones. In this case a "long flue" is one over 16 feet in length.

S. M. VAUCLAIN.

2. What is the most satisfactory way of setting flues in the fire-box tube sheet, and what is the best style and form of tool for setting and repairing them?

P. H. MINSHULL.

3. Grinding as a method of finishing piston rods and crank pins.

H. H. VAUGHAN.

4. New tool steels and effect on shop practice.

S. K. DICKERSON.

5. The steam turbine — its present status.

L. R. POMEROY.

6. What is the slowest factor at the roundhouse?

WILLIAM MCINTOSH.

7. Water purification — results accomplished.

W. R. MCKEEN, JR.

8. Power-house — when are automatic stokers justified? When should economizers be used? When is it advisable to install mechanical draft? What are the elements of an ideal power-house?

WILLIAM FORSYTH.

9. Locomotive smoke consumers. Are they worth while?

WILLIAM GARSTANG.

10. Is it necessary to use two 9½-inch or one 11-inch air pump on freight locomotives?

A. E. MITCHELL.

11. In a locomotive shop what is the smallest number of erecting-shop stalls which will justify the installation of a power riveter with tower, crane and other accessories?

C. A. SELEY.

12. Range of weights of principal parts of locomotives (which are too heavy to be lifted by hand) for use in determining the capacities of cranes and hoists.

R. H. SOULE.

Respectfully submitted,

G. M. BASFORD,
R. D. SMITH,
A. L. HUMPHREY,
Committee.

NEW YORK, May 8, 1903.

On motion, the report was received and referred to the Executive Committee.

THE SECRETARY: I have received word of the death of Mr. William S. Holman, who was connected with the Pennsylvania Railroad Company, and a member of the Association since 1865. The President has named Mr. W. C. Arp as a committee to prepare an obituary on his life. Notice has also been received of the death of Mr. S. A. Hodgman, an honorary member of the Association, who died at Wilmington, Delaware, in November last. The President has suggested Mr. H. D. Gordon to prepare an obituary for incorporation in the Proceedings.

I have the following proposition for associate membership:

To the Members of the American Railway Master Mechanics' Association:

We propose the name of Prof. Gaetano Lanza, of the Massachusetts Institute of Technology, as an associate member.

WM. FORSYTH,
C. H. QUEREAU.

Under the rules the proposition will lie over for one year.

The report of the Auditing Committee was read by the Secretary:

To the Members of the American Railway Master Mechanics' Association:

Your committee have audited the accounts of the secretary and treasurer and find them correct.

L. R. POMEROY,
C. E. FULLER,
Auditing Committee.

On motion of Mr. Hibbard, the report of the Auditing Committee was received.

THE PRESIDENT: We will now receive the report of the Committee on Correspondence and Resolutions.

MR. POMEROY:

To the Members of the American Railway Master Mechanics' Association:

Resolved, That the hearty thanks of the Association be extended to Mr. West for his admirable address, to the Committee of Arrangements for the preparations made by them for the convention, to President Knapp and the village of Saratoga Springs for the hearty welcome, to the proprietors of the Grand Union hotel for their hospitality, to the railroads which extended courtesies, to the Supply Men's Association for their attention, and to the press in general; and it is further

Resolved, That the Association desires to place on record its appreciation and thanks to the *Daily Railway Age* for admirable reports of proceedings, and to the *American Engineer* for the facilities afforded for carrying out the very valuable series of tests on front end appliances at Purdue University.

F. M. WHYTE,
L. R. POMEROY,
Committee on Resolutions.

MR. HUMPHREY: I move that the report of the committee be received and approved.

Motion seconded and carried.

MR. HUMPHREY: Under this head it might not be out of order to make a few remarks in regard to next year's meeting. I believe most of the members feel grateful for the arrangement that has been made by the Pennsylvania Railroad Company and the St. Louis Exposition Company for the testing laboratory that is to be erected next summer at St. Louis. There are a great many members of the Association who will not be able to visit the World's Fair and also attend our convention, which will deprive them of knowledge and experience that they should have, as well as pleasure. For that reason, I offer the following resolution:

Resolved, That the invitation from the president of the Louisiana Purchase Exposition, the Business Men's League of St. Louis, and the mayor of St. Louis, be received with thanks and recommended for favorable consideration by the Executive Committee.

The resolution was unanimously carried.

THE PRESIDENT: The next business is the election of officers.

The Secretary read the list of the present officers and the provisions of the constitution regarding the election of officers.

THE PRESIDENT: One year ago, gentlemen, you promoted me to the office of President of this Association. It seemed to me at that time that you had conferred upon me the greatest honor and pleasure you possibly could. I feel, however, that the large attendance, the strict attention to business and the many courtesies shown to me at this meeting is an honor greater than the one shown me a year ago, for which I can find no words to express my feelings of gratitude. I hope the same earnest support will be given to my successor. [Applause.]

I will appoint Mr. H. Wade Hibbard and Mr. C. E. Fuller as tellers of the ballots. You will now prepare your ballot for the election of a president.

Mr. W. G. Wallace: In behalf of the Traveling Engineers' Association, I wish to thank you for the kind and courteous treatment I have received during your convention. I have not taken a very active part in the discussions of this meeting, which privilege you kindly granted me, because the subjects are beyond the traveling engineer. Our duties are to accept what we have, go out on the road and make the best of it, which we aim to do. I am pleased to report to my association that you so heartily indorse our work, and we hope to be able to submit for your approval a front end that will meet the requirements of modern power at our next convention. That is one of the subjects for our next meeting. We are in favor of doing away with the petticoat or pipe in the front end, as we often have failures on account of the pipe getting loose and requiring adjustment. At other times men come in and report the necessity of an alteration in the pipe, possibly to shield a fireman who is not up to standard, or for other causes. That is one of our most interesting subjects for our next meeting, and we hope to be able to submit something to you that you may be able to approve of. Thanking you again, I wish to say that I have had a very pleasant time here and am glad to have been with you. [Applause.]

The President: Have all the members voted for president who desire to do so. If so, the polls will be declared closed. The tellers will count the ballots and report the result.

Mr. Hibbard stated the result of the ballot for president as follows: Total votes cast, 59; necessary to choice, 30. W. H. Lewis, 32; P. H. Peck, 12; J. F. Deems, 11; G. W. West, 3; C. H. Quereau, 1.

On motion of Mr. Peck, the election of Mr. Lewis as president was made unanimous.

The President: As Mr. Lewis is not present, it will be necessary for your president to hold over until you elect a first vice-president. You will prepare your ballots for first vice-president.

The President: Have all the members voted for first vice-president who desire to do so. If so, the polls will be declared closed. The tellers will count the ballots and report the result.

Mr. Hibbard stated the result of the ballot for first vice-president, as follows: Total vote cast, 62; necessary for choice, 32. P. H. Peck, 44; J. F. Deems, 14; C. H. Quereau, 2; David Brown, 1; F. H. Clark, 1.

On motion the election of Mr. Peck was made unanimous.

President West: Mr. Peck having received the highest number of votes cast, has been elected to the office of vice-president. In turning over the gavel to Mr. Peck I can only repeat what has been already said, that during my whole career in the railroad business it will be my purpose to sustain the Association.

Professor Goss: Mr. Chairman: Believing that members have found unusual pleasure in the efficient manner with which the sessions of this convention have been conducted and that they highly appreciate the uniform courtesy which has marked the rule of its presiding officer, I move that the thanks of the Association be extended to our retiring President, Mr. George W. West.

The motion was unanimously carried by a rising vote.

On suggestion of the Secretary, Mr. George A. Post, representing the supply men, was invited to address the meeting.

Mr. Post entertained the members with a witty story, and then said:

Mr. West, you have been highly honored by your fellow members of the Master Mechanics' Association. You have richly deserved the distinction which has been conferred upon you. You have filled the high post of honor with distinguished credit to yourself and to the members of the craft. Your name is now written on the roll of those eminent men preceding you, who have reached the top of the ladder in this Association, and now, as you lift your feet off of the ladder to plant them upon the corridor of successful achievement, I beg the privilege of handing to you this past-president's badge, which tells its story of the fruition of creditable ambition and of the results of faithful and intelligent effort. If I were to say to you all the kind and complimentary things that dwell in the hearts and on the lips of your friends,

I am afraid it would not be possible to bring this meeting to an adjournment within a reasonable time. I, therefore, take refuge in silence, which will save time and give your imagination a chance to work.

President West: I can only ask you to extend to the supply men, as I have already done to the Master Mechanics' Association, my sincere thanks for the kindness and honor you have bestowed upon me.

A ballot was then ordered for second vice-president.

The Chairman: Have all the members voted for second vice-president who desire to do so? If so, the ballot will be declared closed. The tellers will count the ballots and report the result.

Mr. Hibbard stated the result of the ballot for second vice-president as follows: The total votes cast, 60; necessary to choice, 31. F. H. Ball, 42; J. F. Deems, 13; William McIntosh, 1; Mr. J. E. Sague, 1; F. H. Clark, 1; A. L. Humphrey, 1; H. H. Vaughan, 1.

On motion, the election of Mr. Ball was made unanimous.

The ballot was prepared for third vice-president.

The Chairman: Have all the members voted for third vice-president who desire to do so? If so, the ballot will be declared closed. The tellers will count the ballots and report the result.

Mr. Hibbard stated the result of the ballot for third vice-president as follows: Total votes cast, 61; necessary to choice, 31. J. F. Deems, 21; A. L. Humphrey, 11; William McIntosh, 8; F. H. Clark, 8; H. T. Bentley, 3; G. L. Fowler, 2; C. H. Quereau, 2; and six scattering.

There being no election, a second ballot was ordered.

The Chairman: Have all the members voted the second ballot for third vice-president who desire to do so? If so, the ballot will be declared closed. The tellers will count the ballots and report the result.

Mr. Hibbard stated the result of the second ballot for third vice-president as follows: Total votes cast, 65; necessary to choice, 33. J. F. Deems, 34; A. L. Humphrey, 19; William McIntosh, 5; F. H. Clark, 4; and scattering 3.

On motion of Mr. Humphrey, the election of Mr. Deems was made unanimous.

The ballot was ordered for treasurer.

THE CHAIRMAN: Have all the members voted for treasurer who desire to do so? If so, the ballot will be declared closed. The tellers will count the ballots and report the result.

Mr. Hibbard stated the result of the ballot for treasurer, as follows: Total votes cast, 43. Angus Sinclair, 39; G. M. Basford, 4.

On motion, the election was made unanimous.

THE SECRETARY: Mr. E. W. Grieves has been proposed for associate membership by Mr. George W. West and Mr. John Mackenzie. Under the rules this proposition will lie over till the next meeting.

On motion, the meeting adjourned.

STANDARDS ADOPTED BY THE AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.

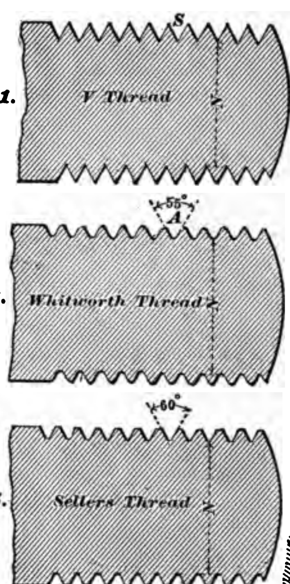
SCREW THREADS, BOLT HEADS AND NUTS.

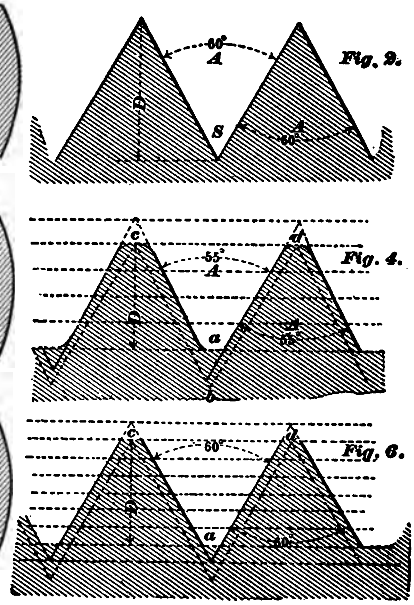
At the convention of 1870 the report of a committee recommending the United States Standard Screw Thread was adopted. The forms and dimensions of the threads are shown below:

Fig. 1.

Fig. 3.

Fig. 5.





SCREW THREADS.　　SELLERS' STANDARD.

Mr. Sellers, who proposed this system of screw threads, described it in an essay read before the Franklin Institute of Philadelphia, April 21, 1864, as follows:

"The proportions for the proposed thread and its comparative relation to the sharp and rounded threads, will be readily understood from the accompanying diagram in which Figs. 1 and 2 — the latter on an exaggerated scale — represent a sharp thread, Figs. 3 and 4 a rounded top and bottom to the English proportion, and Figs. 5 and 6 the flat top and bottom, all of the same pitch. The angle of the proposed thread is fixed at sixty degrees, the same as the sharp thread, it being more readily obtained than fifty-five degrees; and more in accordance with the general practice in this country. Divide the pitch, or, which is the same thing, the side of the thread into eight equal parts, take off one part from the top and fill in one part in the bottom of the thread, then the flat top and bottom will equal one-eighth of the pitch; the wearing surface will be three-quarters of the pitch, and the diameter of screw at bottom of the thread will be expressed by the formula:

$$\textit{Diameter} - \frac{1{,}299}{\textit{number of threads per inch.}}$$

At the convention of 1892 the Association adopted as standard the United States standard sizes of nuts and bolt heads.

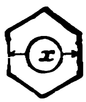
At the convention of 1903 the arrangement of these standards was made to conform to the arrangement as adopted by the Master Car Builders' Association.

The accompanying tables are reprinted from Mr. Sellers' essay. They give the proportions of his standard screw threads, nuts and bolt heads.

PROPORTIONS FOR SELLERS' STANDARD SCREW-THREADS, NUTS AND BOLTS.

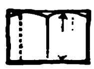
Screw-Threads.				Nuts.				Bolt Heads.			
Diameter of screw.	Threads per inch.	Diameter at root of thread.	Width of flat.	Short diameter rough.	Short diameter finish.	Thickness rough.	Thickness finish.	Short diameter rough.	Short diameter finish.	Thickness rough.	Thickness finish.
1/4	20	.185	.0062	1/2	7/16	1/4	3/16	1/2	7/16	1/4	3/16
5/16	18	.240	.0074	19/32	17/32	5/16	1/4	19/32	17/32	19/64	1/4
3/8	16	.294	.0078	11/16	5/8	3/8	5/16	11/16	5/8	11/32	5/16
7/16	14	.344	.0089	25/32	23/32	7/16	3/8	25/32	23/32	25/64	3/8
1/2	13	.400	.0096	7/8	13/16	1/2	7/16	7/8	13/16	7/16	7/16
9/16	12	.454	.0104	31/32	29/32	9/16	1/2	31/32	29/32	31/64	1/2
5/8	11	.507	.0113	1 1/16	1	5/8	9/16	1 1/16	1	17/32	9/16
3/4	10	.620	.0125	1 1/4	1 3/16	3/4	11/16	1 1/4	1 3/16	5/8	11/16
7/8	9	.731	.0138	1 7/16	1 3/8	7/8	13/16	1 7/16	1 3/8	23/32	13/16
1	8	.837	.0156	1 5/8	1 9/16	1	15/16	1 5/8	1 9/16	13/16	15/16
1 1/8	7	.940	.0178	1 13/16	1 3/4	1 1/8	1 1/16	1 13/16	1 3/4	29/32	1 1/16
1 1/4	7	1.065	.0178	2	1 15/16	1 1/4	1 3/16	2	1 15/16	1	1 3/16
1 3/8	6	1.160	.0208	2 3/16	2 1/8	1 3/8	1 5/16	2 3/16	2 1/8	1 3/32	1 5/16
1 1/2	6	1.284	.0208	2 3/8	2 5/16	1 1/2	1 7/16	2 3/8	2 5/16	1 3/16	1 7/16
1 5/8	5 1/2	1.389	.0227	2 9/16	2 1/2	1 5/8	1 9/16	2 9/16	2 1/2	1 9/32	1 9/16
1 3/4	5	1.491	.0250	2 3/4	2 11/16	1 3/4	1 11/16	2 3/4	2 11/16	1 3/8	1 11/16
1 7/8	5	1.616	.0250	2 15/16	2 7/8	1 7/8	1 13/16	2 15/16	2 7/8	1 15/32	1 13/16
2	4 1/2	1.712	.0277	3 1/8	3 1/16	2	1 15/16	3 1/8	3 1/16	1 9/16	1 15/16

PROPORTIONS FOR SELLERS' STANDARD NUTS AND BOLTS.

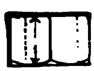


Rough Nut = one and one-half diameter of bolt $+ \frac{1}{8}$.

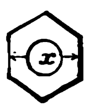
Finished Nut = one and one-half diameter of bolt $+ \frac{1}{16}$.



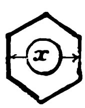
Rough Nut = diameter of bolt.



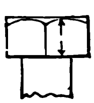
Finished Nut = diameter of bolt—$\frac{1}{16}$.



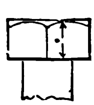
Rough Head = one and one-half diameter of bolt $+ \frac{1}{8}$.



Finished Head = one and one-half diameter of bolt $+ \frac{1}{16}$.



Rough Head = one-half distance between parallel sides of head.



Finished Head = diameter of bolt—$\frac{1}{16}$.

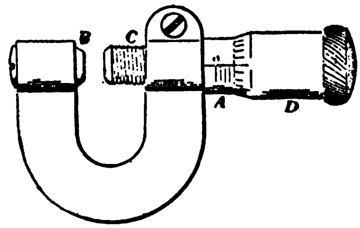
SQUARE BOLT HEADS.

In 1899 the following dimensions for square bolt heads were adopted as standard:

The side of the head shall be one and one-half times the diameter of the bolt, and the thickness of the head shall be one-half the side of the head.

SHEET METAL GAUGE.

At the convention of 1882 the Brown & Sharpe micrometer gauge shown below was adopted as standard for the measurement of sheet metal (see page 132, report 1882). Reaffirmed 1891 (see pages 160, 161, report 1891).



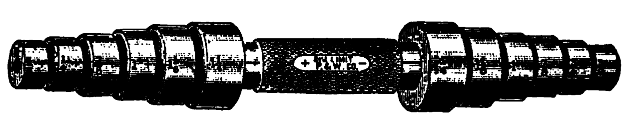
DISTANCE BETWEEN BACKS OF FLANGES.

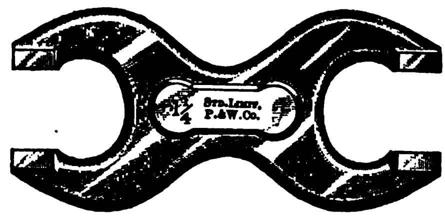
At the convention of 1884 a motion prevailed that the standard distance between the backs of tires for tender locomotive truck and driving wheels be not less than 4 feet 5⅛ inches, nor more than 4 feet 5½ inches. (See page 26, report 1884.) Modified in 1903. See report of Committee on Revision of Standards.

LIMIT GAUGES FOR ROUND IRON.

At the convention of 1884 the Pratt & Whitney limit gauges for round iron, shown below, were adopted as standard. (See page 168, report 1884.) Reaffirmed 1891 (see pages 160, 161, report 1891).

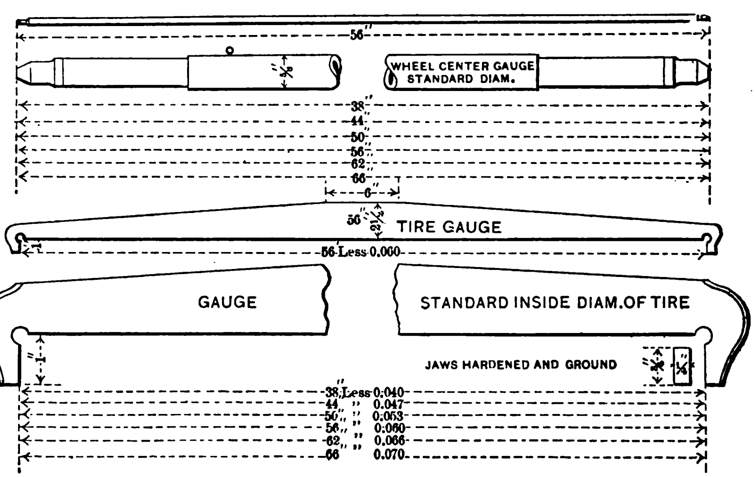
Nominal Diameter. Of Iron. Inches.	Large Size, End. Inches.	Small Size, End. Inches.	Total Variation. Inches.
¼	.2550	.2450	.010
5/16	.3180	.3070	.011
⅜	.3810	.3690	.012
7/16	.4440	.4310	.013
½	.5070	.4930	.014
9/16	.5700	.5550	.015
⅝	.6330	.6170	.016
¾	.7585	.7415	.017
⅞	.8840	.8660	.018
1	1.0095	.9905	.019
1 ⅛	1.1350	1.1150	.020
1 ¼	1.2605	1.2395	.021





DRIVING WHEEL CENTERS AND SIZES OF TIRES.

At the convention of 1886 the report of a committee was adopted which recommended driving-wheel centers to be made 38, 44, 50, 56, 62 or 66 inches diameter. At the Twentieth Annual Convention the recommendations of a committee were adopted, making tire gauges manufactured by Messrs. Pratt & Whitney, Hartford, Connecticut, and here illustrated, standards of the Association. The sizes and the allowance for shrinkage are as follows:



At the Twenty-sixth Annual Convention the following sizes were adopted as standards for large driving wheels: 70, 74, 78, 82, 86 and 90 inches.

Reaffirmed in 1891 (see pages 160, 161, report 1891).

SECTION OF TIRE.

At the convention of 1893 the standard forms of tires shown on Plate I were adopted as standard. Railroad companies ordering tires will save time by specifying these forms.

At the convention of 1896 a minimum thickness of 1 inch for the flanges of engine and truck wheels was adopted as standard practice; determination to be made by M. C. B. flange thickness gauge. (See Proceedings for 1896.)

BOILER AND FIRE-BOX STEEL SPECIFICATIONS.

Adopted in 1894. (See pages 68-92, report 1894.)

Special Requirements for Sheet Steel.

Tensile strength, 55,000 pounds to 65,000 pounds. Elongation not less than 20 per cent in 8 inches.

Test piece after having rough edges removed by filing, grinding or machining shall, without annealing, bend over on itself, both while cold and after being heated to cherry red and dipped in water at 80 degrees Fahrenheit, without showing cracks or flaws on outside edge.

No chemical requirements.

Special Requirements for Fire-box Steel.

Metal to have tensile strength of from 55,000 pounds to 65,000 pounds, with 60,000 pounds desired; elongation, 28 per cent.

Chemical Requirements.

Carbon	.18 per cent
Phosphorus, not above	.03 per cent
Manganese, not above	.40 per cent
Sulphur, not above	.02 per cent
Silicon, not above	.02 per cent

Plates will be rejected having:

1. Tensile strength less than 55,000 pounds.
2. Tensile strength over 65,000 pounds.
3. Elongation less than 22 per cent in 8 inches, and in ¼-inch plates not less than 20 per cent in 8 inches.
4. Failure to stand bending and quenching test as for sheet steel.
5. Any seam or cavity more than ¼ inch long in any of the fractures of homogeneity test.
6. Carbon, over .25 per cent.
7. Carbon, below .15 per cent.
8. Phosphorus, over .035 per cent.
9. Manganese, over .45 per cent.
10. Silicon, over .03 per cent.
11. Sulphur, over .035 per cent.

Homogeneity Test.

A portion of the broken test piece should be nicked with chisel on opposite sides alternately, the nicks being about 1 inch apart. Test piece should then be firmly held in vise and broken by a number of light blows, the bending being away from the nicks. Laminations more than ¼ inch long will condemn.

Test Pieces.

Test pieces, one from each plate, shall be in rough, 2 inches wide and 36 inches long, and as nearly straight and free from twist as possible, and in no case must be annealed. Each plate shall bear the maker's name, either rolled or stamped. The heat number and, in addition, such identification marks as may be specified by ordering road, shall be put on each plate and test piece.

When inspectors are present at mills, butt strips may be cut from any plate, provided such sheets are represented by test coupons. Where inspectors are not at mills, they must, as far as possible, be cut from a single sheet as rolled, and each sheet cut into butt strips will be represented by a test strip. All butt strips as well as test strips shall bear the heat number.

Shear Marks.

Each sheet shall be accompanied by a test coupon, 2 by 36 inches long, attached at one end to sheet. To facilitate future matching, should it be necessary, both sheet and coupon shall be stamped twice across division line with a shear mark, either round, oval or of other agreed form, which mark should be not less than 3 inches across.

In cases where one large plate is cut into several smaller ones, all represented by one test piece, the same shear mark shall be stamped across each division line in two places before shearing, so that subsequent identification may be readily performed.

Dimensions.

Plates must be of shape and dimensions ordered. Any excess in weight over that corresponding to the dimensions in the order, greater than that specified in the table below, will not be paid for.

In computing weight of plate from dimensions, one cubic inch will be taken as weighing 0.2830 of a pound.

Allowance for overweight over that corresponding to dimensions:

For plates [illegible] inch thick	10	per cent.
[illegible]	8	"
[illegible]	7	"
[illegible]	6	"
[illegible]	5	"
[illegible]	4½	"
[illegible]	4	"

[illegible] less in thinnest part than that [illegible] or cracks at the sheared edges, [illegible] have cracks, slivers or depressions in the surface, or which [illegible] be rejected. Rejection on account of [illegible] after measurement of the actual sheet. Test

pieces being prepared from the edge of sheet are liable to be thinner than the main sheet.

Test pieces when finished will be 1½ inches wide in test section, and of full thickness of plate, and may be either parallel sided or of reduced section, and prepared either by longitudinal planing or milling. Where reduced section is adopted, the distance between bottom of fillets shall be not less than 9 inches, and the radius of fillets shall be not less than ½ inch, and preferably more.

Elongation will be measured between tram punch marks originally 8 inches apart, and on reduced sections placed approximately equidistant between fillets. In parallel sided sections the tram punch may be applied at more than one point to insure breakage occurring between the marks.

STANDARD METHOD OF CONDUCTING EFFICIENCY TESTS OF LOCOMOTIVES.

In 1894 a method of conducting tests of locomotives was submitted by a committee of the Association, and on motion adopted as a standard of the Association. (See page 200, report 1894.)

The tests are as follows:

*A. Preparations for Test and Location of Instruments.**

1. The locomotive should be put in good condition preparatory to the test. The boiler and tubes should be tight, and both the interior and exterior surfaces should be clean, and, if possible, free from scale. There should be no lost motion in the valve gear, and the valves should be set properly. No change in the engines should be allowed during the progress of a series of tests, unless so ordered for the purposes of the trial.

A glass water-gauge should be fitted to the boiler, if not already provided, and side of it there should be a graduated scale to assist in correcting water quantities, caused by change of inclination of the boiler, and difference of levels when beginning and ending a test. The notches on the quadrant should be marked by large figures, so that they can be read by the cab assistant. The throttle valve lever should be provided with a scale so as to show the degree of opening of the throttle valve.

The point of cut-off of the valves should be determined for each notch in the quadrant.†

2. The valves and pistons should be tested for leakage with the engine at rest. The steam valve can be tried by setting the engine so that the valve on one side will be at the center of its throw, in which position both ports are usually covered, and pulling open the throttle valve, blocking the drivers if there is a tendency for the engine to be set in motion. Leakage of the valve, if any occurs, will show itself by escaping at the

* The directions here given apply largely to both shop and road tests, but especially the latter.

† See appendix for description of valve diagram apparatus used on Norfolk & Western Railway.

open cylinder cocks. The tightness of the piston may be tested by setting the engine so that it makes steam, blocking the drivers and opening the throttle valve. This should be tried first on one cylinder and then on the other, and, if desired, it may be tried with the pistons at various points in the stroke. The leakage, if any occurs, will be shown at the open cylinder cock.

3. The following instruments should be verified or calibrated: Steam gauges, draft gauge, pyrometer, thermometers for calorimeter and feed-water, water meter, tank, revolution counter, indicator springs, dynamometer springs and dynamometer recording mechanism. The radiation loss on the steam calorimeter should be determined, or the normal readings ascertained,* and the quantity of steam which passes through the instrument in a given time should be measured.

4. The quantities of steam used by the various auxiliaries of the locomotive can be determined by noting the change in weight of the engine standing upon scales while they are each in use under the usual conditions for known times. Similarly leakage of water and steam can be determined. The quantities can then be properly deducted from the total water used.

5. To facilitate the measurement of coal and the determination of the quantity used during any desired period of the run, it is desirable to provide a sufficient number of sacks of a size holding a weight of, say, 100 pounds, and weigh the coal into these sacks preparatory to starting on the test. If desired, the sacks may be numbered to facilitate the accuracy of record.

6. The instruments and other apparatus that should be provided and their locations are as follows:

To facilitate the work of operating the indicators and reading the instruments at the front end, the smoke-box should be surrounded with a wooden fence, or "pilot-box," as it may be called, resting on the top of the cow-catcher, and extending back far enough to inclose also the sides of the cylinders. This box is floored over above the cylinder heads, and the inclosure thus provided forms a convenient place for the accommodation of the assistants at this end of the locomotive, and it affords them some measure of protection against wind and rain, as also the joltings and vibrations due to rapid travel.

A special steam-gauge with a long siphon is to be used for registering the boiler pressure. It can best be located on the left-hand side of the cab.

The indicator apparatus which is most suitable consists of a three-way cock for the attachment of the indicators, and some form of pantagraph or other correct reducing motion for the driving rig. The pipes leading from the cock to the cylinder should be ¾ inch diameter inside, and they should connect into the side of the cylinder rather than into the two heads. The indicator should also be piped so that a steam-chest diagram can be drawn by it, and from this the steam-chest pressure determined.

* Transactions A. S. M. E., Vol. XI, page 793.

Sharp bends in the pipe should be avoided, and they should be well covered, to intercept radiation. The three-way cock should be provided with a clamp rigidly secured to the cylinder, and thus overcome any tendency of the indicators to move longitudinally with reference to the driving rig. Absolute rigidity is highly essential in this particular. Two forms of pantagraph motion are shown in Figs. 1 and 2. In both of these the reduced motion is transmitted to the indicator through a light rod, working horizontally. By this means a cord eight or ten inches in length is sufficient for connection to the indicator. Care should be taken to set the instrument in such a position that the cord pin in the end of the rod travels in a direction pointing to the groove in the paper drum. Pantagraph motions arranged as noted are preferable to the common pendulum and quadrant reducing mechanism, with its long stretch of cord. For another type of correct reducing motion see appendix.

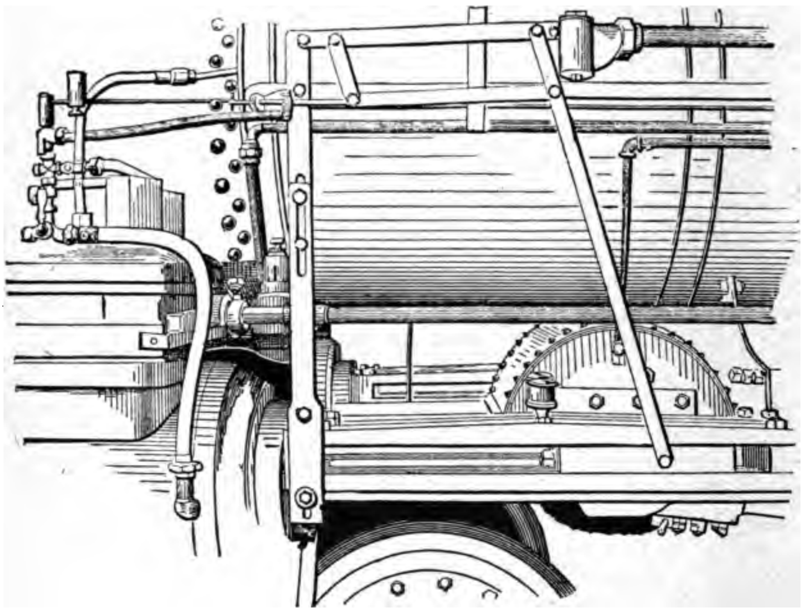
A draught gauge consisting of a U tube containing water, properly graduated in inches, should be placed in the cab and connected to the smoke-box by a ⅜-inch pipe. This long pipe steadies the water, and the readings can be taken by the cab assistant.

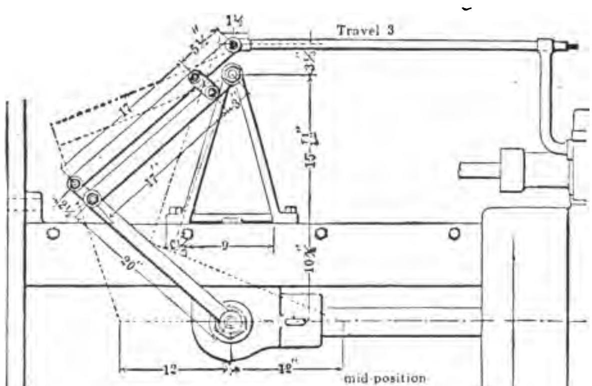
A pyrometer for showing the temperature of the escaping gases should be used in a position below the tip of the exhaust nozzles.

The calorimeter should be attached either to the steam dome at a point close to the throttle opening or to the steam passages in the saddle casting on one side, according as it is desired to obtain the character of the steam at one point or the other. The former location is preferred by the committee. A perforated ½-inch pipe should be used for sampling and conveying the steam to the calorimeter pipe. For descriptions of various forms of calorimeters which are adapted to locomotive use, see Trans. A. S. M. E., Vol. X, page 327; Vol. XI, page 790; Vol. XII, page 825.

The water meter should be attached to the suction pipe of the injector, and located at a point where it can be conveniently read when the locomotive is running. It should be provided with a check valve to prevent hot water from flowing back to it from the injector and a strainer to intercept foreign material.

To measure the depth of the water in the tank a metallic float should be used carrying a vertical tube which slides upon a graduated rod, the lower end of which rests upon the bottom of the tank. This should be placed at the center of gravity of the water space. If the desired location cannot be used, provision should be made for ascertaining the level or inclination of the tank. The best device for this purpose is a plumb line of a certain known length, provided at the bottom with a double horizontal scale having one set of divisions parallel to the side of the tank and the other set at right angles to it. From the readings on these scales referred to, the length of the line, the level of the tank in both directions can be ascertained. A similar device should be attached to the boiler to





Rigid Non Adjustable

correct for the variation of its inclination.* The plumb line may be conveniently attached for this purpose at some point near the front end.

The revolution counter should be placed near the front end of the engine, in plain view of the pilot-box. It is operated through a belt from the driver axle. This recommendation applies to that form of counter which shows at a glance the exact speed in revolutions per minute.

A stroke counter should be provided for showing the number of strokes made by the air-pump.

Electric connection should be made between the dynamometer car and cab, so that dynamometer records and indicator diagrams may be taken simultaneously. Another desirable provision is a speaking-tube leading from the dynamometer car to the locomotive cab, and one also to the pilot-box.

7. It is needless, except for a complete record of directions for preparatory work, to call attention to the desirability of having the test, and especially the road test, made under the supervision of a competent person, who is not only familiar with the details of the testing, but also with the proper method of firing and mechanical operation of the locomotive. This is a most important factor, for it is only the clear-headed and able experimenter who is likely to obtain satisfactory work in this most difficult department of engineering tests.

The conductor of the test is best able to determine the number of assistants required, the various duties of the men, and the manner of making records. In general, three (3) men are sufficient to conduct a locomotive test, one (1) being at each cylinder, and one (1) in the cab for taking records.

The men at the cylinders will take indicator diagrams, and one will read the revolution counter and the pyrometer. The indicator papers will be numbered in consecutive order for each cylinder before the test begins, and when the diagram is taken the papers will be deposited through a slot in a box near each assistant.

The cab assistant notes the time of leaving and arriving at stations, the position and time of opening and closing the throttle, the time of taking indicator diagrams, for which he shall determine the time and give the signal by any effective means; the time of blowing off, the time the blower is applied, the number of applications of the injector, the position of the reverse lever, the steam pressure, the draught gauge, the time of passing important stations, the readings of the water glass, meter and air-pump counter, the number of sacks of coal used, the reading of the tank float, the temperature of the feed-water and atmosphere, the direction and force of the wind, the condition of the rail and state of the weather. Many of these readings are as nearly as possible simultaneous with the signal for taking indicator diagrams, and one experienced man in the cab will have no difficulty in entering all of these records in a note-

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* See appendix for description of special devices used on the Norfolk & Western Railway for this purpose.

book properly prepared with ruled columns and headings. In case of short stops at stations, one of the men at the indicators can take the tank float observations, or any observation that is advisable at stations. The weights of coal placed upon the tender have been checked by these two persons when weighing it out to the engine. One man takes the level of the boiler at stopping-places where this is required.

When the calorimeter and smoke-box gas samples are used another assistant is required.

In the dynamometer car two (2) men are required, who record the time of each start and stop, the time of passing each station and mile-post, time of taking each indicator diagram as obtained from the signal given by the cab assistant, and all these events are marked on the dynamometer paper. These men, as well as one of the engine assistants, will note the direction and force of the wind, the temperature of the atmosphere and condition of the weather.

8. It is of great importance, after the preparatory work has been accomplished, that a preliminary run be made with the locomotive, in order to fairly test the apparatus and to accustom the men to their duties.

B. The Dynamometer Car.

With a suitable dynamometer car the force required to move the train, or the pull upon the drawbar, is registered upon a strip of paper traveling at a definite rate per mile. The scale upon which this diagram is drawn should be as large as is possible within reasonable limits. A scale of ¼ inch per 1,000 pounds pull is suitable, as the maximum registered pull rarely exceeds 30,000 pounds.

The height of the diagram should be measured from a base line drawn upon the paper by a stationary pen, so located that when no force is exerted upon the drawbar the base line should coincide with zero pull.

The apparatus should be arranged to make a record of time marks in connection with the curve showing the pull. A chronometer should be provided having an electric circuit-breaker, by means of which a mark is made on the dynamometer paper every five (5) seconds. A better apparatus may be used in which a continuous speed curve is traced upon the paper parallel to the curve of pull. The ordinates of this curve, measured from a base line, give the speeds desired.

The location of mile-posts and other points along the route should be fixed upon the dynamometer paper by employing an additional pen, and operating it by means of electric press buttons, which are placed at convenient points in the car.

As already noted, a similar device should be provided for marking upon the dynamometer paper the time of taking indicator diagrams.

The rate of travel of the paper per mile should be such that one inch measured upon the diagrams represents 100 feet for short-distance work, and for long-distance work ½ inch to ¼ inch should be used to represent 100 feet of track. The driving mechanism for the paper should be so

arranged that it can be changed to give these three proportions. It is necessary to have all the registering pens located upon the same transverse line at a right angle with the direction of the movement of the paper in order that simultaneous data may be recorded.

C. Method of Conducting the Road Test.

The locomotive having been brought to the train, the steam pressure being at or near the working point, the fire being clean and in good condition, the ash-pan being also clean, observations are taken, say, five (5) minutes before starting time, of the thickness and condition of the fire, the height of water in the boiler, the depth in the tank, the levels, the water meter and the air-pump counter, and thereafter the regular observations are carried forward, and coal is fired from the weighed sacks.

Indicator diagrams should be taken as frequently as possible, the intervals between them being not over two minutes.

Other regular observations should be taken at close intervals. Calorimeter readings, when taken, should be continued for at least five (5) minutes at one minute intervals.

At water stations careful records should be obtained of water heights and levels of boiler and tank.

As the end of the route is approached, the fire should be burned down so as to leave the same amount and the same condition as at the start. When the end is finally reached the fire should be raked and its condition carefully noted. If it differs from that which obtained at the beginning, an estimated allowance must be made for such difference.

At the close of the test the height of water in the boiler should be the same as at the beginning, or, if not, the difference, corrected for inclination of the boiler, should be allowed for.

During the process of weighing the coal into the sacks numerous samples should be obtained and placed in a covered box, and a final sample of these selected. This is to be dried and subjected to chemical analysis and calorimeter test. The sample is weighed before and after drying, and data obtained for determining the weight of dry coal used during the test. The temperature of the feed-water can be best taken at the tank cock, in order to obtain that of a mixed sample.

The duration of the road test is the length of time which the throttle valve is open.

D. The Data and Results.

The data and results of the road test may be tabulated in the form given in Table No. 1. This form corresponds in general with that recommended for shop test, namely, Table No. 2.

TABLE No. 1.

Data and Results of Road Test on....Engine, Made....189 .

General dimensions, etc. (to be accompanied by a complete description of engine with drawings and dimensions, also of train and route):

1. Kind of engine ....
2. Size of cylinders..
3. Clearance of cylinders ....per cent
4. Area of heating surface ....sq. ft.
5. Area of grate surface..sq. ft.
6. Size of exhaust nozzles ....inches
7. Average weight of locomotive and tender (including water)....tons
8. Number of cars ....
9. Weight of cars ....tons
10. Length of route ....miles
11. Number of ton-miles of train load ....ton-miles
12. Number of ton-miles of total load........................ton-miles
13. Schedule time of trips..

Total Quantities.

14. Duration or time throttle valve is open ....hours
15. Weight of dry coal burned ....lbs.
16. Weight of water evaporated, corrected for moisture in the steam and loss at injector*....................................lbs.
17. Weight of ashes and refuse taken from ash-pan..................lbs.
18. Weight of cinders from smoke-box ....lbs.
19. Percentage of ash as found by coal calorimeter test..........per cent
20. Total heat of combustion as found by calorimeter test ....B. T. U.
21. Results of chemical analysis of coal ....

Power Data.

22. Mean effective pressure, H. P. cyls................................lbs.
23. Mean effective pressure, L. P. cyls................................lbs.
24. Average revolutions per minute....................................rev.
25. Indicated horse-power, H. P. cyls..............................H. P.
26. Indicated horse-power, L. P. cyls..............................H. P.
27. Indicated horse-power, whole engine............................H. P.
28. Pull on draw-bar..lbs.
29. Dynamometer horse-power ....H. P.

Averages of Observations of Instruments.

[illegible] Average boiler pressure ....lbs.
[illegible] Average steam-chest pressure ....lbs.
[illegible] Average temperature of smoke-box ....°
[illegible] Average draught in [illegible] ....°
[illegible] Average temperature of feed-water ....°
[illegible] Average temperature of atmosphere ....°
[illegible] Average percentage of moisture in the steam..................per cent
[illegible] [illegible] percentage of moisture in the steam ....per cent
[illegible] ....

* [illegible] air-pump, blower, safety valve [illegible]

Other Data.

39. Average position of throttle..
40. Average position of reversing lever..............................
41. Average speed in miles per hour...................................
42. Maximum speed in miles per hour..................................
43. Number of stops..
44. Average number of strokes of air pump per minute.................
45. Total estimated weight of steam used by air pump per hour......lbs.
46. Estimated loss of steam at safety valve per hour..................lbs.
47. Estimated loss of steam at whistle per hour.....................lbs.
48. Estimated weight of steam used by blower per hour...............lbs.
49. Estimated loss of steam at calorimeter per hour..................lbs.

Hourly Quantities.

50. Weight of dry coal burned per hour.............................lbs.
51. Weight of dry coal burned per hour per square foot of grate surface ....lbs.
52. Weight of coal burned per square foot of heating surface........lbs.
53. Weight of water evaporated per hour...........................lbs.
54. Equivalent weight of water evaporated per hour with feed-water at 100° and pressure 70 lbs..........................lbs.
55. Equivalent weight of water from 100° at 70 lbs. evaporated per square foot of heating surface..........................lbs.
56. Weight of water consumed by engine cylinder (line 53, less sum of lines 45, 46, 47, 48 and 49)..........................lbs.

Principal Results — Complete Engine and Boiler.

57. Coal consumed per I. H. P. per hour............................lbs.
58. Coal consumed per dynamometer horse-power per hour...........lbs.
59. Coal consumed per ton-mile of train load........................lbs.
60. Coal consumed per ton-mile of total load.......................lbs.
61. Weight of standard coal consumed per I. H. P. per hour.........lbs.
62. Weight of standard coal consumed per dynamometer horse-power per hour..lbs.
63. Weight of standard coal consumed per ton-mile of train load....lbs.
64. Weight of standard coal consumed per ton-mile of total load.....lbs.

Boiler Results.

65. Water evaporated per pound of coal ....lbs.
66. Equivalent evaporation per pound of coal from and at 212°......lbs.
67. Equivalent evaporation per pound of combustible from and at 212° ....lbs.
68. Heat imparted to each pound of steam used from average temperature of feed at average steam pressure in British thermal units...

Cylinder Data.

		H. P. Cyl.	L. P. Cyl.
69.	Mean initial pressure above atmosphere..........lbs.		
70.	Cut-off pressure above zero..........lbs.	......	......
71.	Release pressure above zero ....lbs.	......	......
72.	Compression pressure above zero..........lbs.	......	......
73.	Lowest back pressure above or below atmosphere ....lbs.	......	......
74.	Proportion of forward stroke completed at cut-off	......	......
75.	Proportion of forward stroke completed at release	......	......
76.	Proportion of return stroke uncompleted at compression	......	......
77.	Mean effective pressure (lines 22 and 23) lbs.	......	......

Cylinder Results.

78. Total water consumed per indicated horse-power per hour, corrected for moisture in steam..........lbs.

79. Water consumed per I. H. P. per hour by cylinders alone (from line 56)..........lbs.

		H. P. Cyl.	L. P. Cyl.
80.	Steam accounted for by indicators at cut-off.lbs.	......	......
81.	Steam accounted for by indicator at release.lbs.	......	......
82.	Proportion of feed-water used by cylinders (line 79) accounted for at cut-off..........	......	......
83.	Proportion of feed-water used by cylinders accounted for at release..........	......	......
84.	Total heat supplied by boiler to cylinders per hour in British thermal units..........	......	......
85.	Total heat supplied by boiler to cylinders per minute per indicated horse-power in British thermal units..........	......	......
86.	Total heat supplied by boiler to cylinders per minute per dynamometer horse-power in British thermal units	......	......

The following form for the tabulation of the results of locomotive tests will be found convenient. They can, of course, be modified to suit any method of testing, whether standard or not:

LOCOMOTIVE TESTS — GENERAL RESULTS.

....................................*Railroad Co.*
................*Tests of Locomotive No......, between*................
and............................*Distance......Miles. Train No*........
................*Bound.* ...., *18*....
Kind of Coal............................ *Coal Analysis*...............
Calorimetric Value of Coal..

Trip No..
Date ....
Left ....at..............................
Arrived ....at..............................
Left ....at..............................
Arrived ....at..............................

1. Weather ....
2. Mean temperature of atmosphere..................................
3. Direction of wind..
4. Velocity of wind, miles per hour..................................
5. Condition of rails..
6. Weight of train in tons of 2,000 lbs., including locomotive, tender, passengers and freight..
7. Weight of train in tons of 2,000 lbs., excluding the locomotive and tender ....
8. Equivalent number of standard cars at ....tons each.........
9. Size of exhaust nozzle, single or double............................
10. Maximum boiler pressure by gauge................................
11. Minimum " " " " ....
12. Average " " " " ....
13. Prevailing position of throttle (wide open = 1.00)...................
14. " " " reverse lever (notch) ....
15. " points of cut-off ....
16. Schedule time in motion..
17. Actual " " " ....
18. Time made up in minutes..
19. Aggregate intermediate stops, minutes............................
20. Time during which power was developed, or throttle open..........
21. Maximum number of revolutions per minute........................
22. Minimum number of seconds per mile..............................
23. Maximum rate of speed, miles per hour............................
24. Average speed, miles per hour....................................
25. Actual weight of coal fired......................................
26. Moisture in coal, percentage.....................................
27. Dry coal fired...
28. Actual weight of wood used.......................................
29. Total weight of coal fired (wood added at .4).......................

30. Weight of refuse in fire-box and ash-pan........................
31. " unconsumed coal recovered from fire-box and ash-pan.......
32. Total weight of coal consumed (Item 29-31).......................
33. Net weight of ashes in fire-box and ash-pan.........................
34. Weight of cinders (sparks) in smoke-box.........................
35. Percentage of ash in coal...
36. " " " cinders (sparks)...................................
37. " " total refuse...
38. Percentage of combustible consumed.............................
39. Weight of combustible utilized...
40. Number of miles run per ton (2,000 lbs.) of coal...................
41. " " pounds of coal used per mile...........................
42. Coal used per ton of train per 100 miles...............................
43. " " " car-mile...
44. Average weight of coal burned per square foot of grate surface per hour ....
45. Total coal per indicated horse-power developed per hour............
46. Average temperature of feed-water.................................
47. Weight of water drawn from tender.............................
48. Waste of injector, leakage, etc...................................
49. Weight of water apparently evaporated (Item 47-48)................
50. Percentage of moisture in steam...................................
51. Water actually evaporated, corrected for quality of steam............
52. Actual evaporation per pound of total coal.........................
53. Equivalent evaporation from and at 212° per pound of coal........
54. " " " " " " " " " combustible.
55. Water used per ton of train per 100 miles...........................
56. " " " car-mile ....
57. " " " hour while developing power.......................
58. " " " indicated horse-power per hour.....................
59. " " " sq. ft. of heating surface, from and at 212°..........
60. " " " " " " grate " " " " ....
61. Maximum indicated horse-power developed.........................
62. Average " " " ....
63. Dry steam used per indicated horse-power, per hour, per indicator diagram ....
64. Average number of sq. ft. of heating surface per indicated horse-power
65. Average number of indicated horse-power per sq. ft. of grate surface.
66. Prevailing temperature in smoke-box while using steam.............
67. " draft in smoke-box while using steam, in inches of water.

SHOP TEST.

A. Preparation and Location of Instruments.

In preparing for a shop test the preparations described for the road test should be followed so far as the nature of the test requires. When

run as a stationary engine the locomotive is not circumscribed by the conditions of road service, and many provisions required on the road are unnecessary. It is unnecessary to determine the quantity of steam consumed by the air pump and auxiliaries, for these are not brought into use on the shop test; and no occasion exists for finding the quantity lost at the safety valve, for on the continuous shop run the steam pressure can be maintained at a uniform point, and blowing off readily prevented. It is unnecessary to use sacks for the convenient measure of coal, because the coal can be readily weighed up in lots as fast as needed for the test. It is unnecessary to provide a "pilot-box," and no fixed location of the instruments is required, as on the road test. The feed-water may be weighed before it is supplied to the tank, and the tank may be used in this case as a reservoir, the float showing its depth. The meter would thus be unnecessary as the principal instrument of measurement, but a meter is in all cases useful as a check upon this most important element in the data. The long indicator pipes required on the road test may be dispensed with, and one indicator applied close to each end of the cylinder, a practice much to be preferred to the use of a three-way cock and the single indicator. The dynamometer car is not required, but its equivalent should be provided, consisting of a dynamometer which registers the pull on the drawbar in the same manner as the device used on the road.

The number of assistants required on a shop test is less than that needed for a road test. A good test can be made with four (4) assistants, distributed as follows:

One assistant for operating indicators.

One assistant for measuring water.

Two (2) assistants for general observations and coal measurement.

B. Conditions of Test.

The test should be continued for a run of at least two (2) hours from the time normal conditions have been established.

At the close of the test the water height in the boiler and the height of water in the tank should be the same as at the beginning, or proper corrections made for any differences which may exist.

The fire-box and ash-pit are then cleaned, and such unburnt coal as may be contained in the refuse is separated, weighed and deducted from the total weight of coal fired. The balance of the refuse is weighed, as also the cinders removed from the smoke-box.

During the progress of the test samples of the various charges of coal should be obtained, and at its close a final sample of these should be selected, dried and subjected to chemical analysis and calorimeter test. The weight of the sample as taken before and after drying to ascertain the weight of moisture contained in the fuel.

C. *The Data and Results.*

The data and results of the shop test can best be arranged in the manner indicated in Table No. 2. So far as these are in common with the data and results obtained on the road test, the forms used on both kinds of test are identical.

TABLE No. 2.

Data and Results of Shop Test on....Engine, made......189.....

General dimensions, etc. (to be accompanied by a complete description, with drawings and full dimensions).

1. Kind of engine..
2. Size and clearance of cylinders.....................................
3. Area of heating surface...
4. Area of grate surface...
5. Diameter of exhaust nozzles.......................................

	Total Quantities.	Whole Run.
6.	Duration ....hrs.	......
7.	Weight of dry coal burned, including .4 weight of wood.lbs.	......
8.	Weight of water evaporated corrected for moisture in the steam ....lbs.	......
9.	Weight of ashes and refuse from ash-pan.............lbs.	......
10.	Weight of cinders from smoke-box.................lbs.	......
11.	Percentage of ash as found by calorimeter test....per cent	......
12.	Total heat of combustion per lb. coal as found by calorimeter test............................B. T. U.	....
	Power Data.	
13.	Mean effective pressure, high-pressure cylinders......lbs.	......
14.	Mean effective pressure, low-pressure cylinders........lbs.	......
15.	Average revolutions per minute....................rev.	......
16.	Indicated horse-power, high-pressure cylinders.....H. P.	......
17.	Indicated horse-power, low-pressure cylinders.......H. P.	......
18.	Indicated horse-power, total......................H. P.	......
19.	Pull on drawbar ....lbs.	......
20.	Dynamometer horse-power ....H. P.	......
	Averages of Observations.	
21.	Average boiler pressure...........................lbs.	......
22.	Average steam-chest pressure......................lbs.	......
23.	Average temperature of smoke-box...................°	......
24.	Average draught suction..........................″	......
25.	Average temperature of feed-water ....°	......
26.	Average temperature of atmosphere...................°	......
27.	Average percentage of moisture in the steam....per cent	......
28.	Maximum percentage of moisture in the steam...per cent	......

Hourly Quantities.

			Whole Run.
29.	Weight of dry coal burned per hour	lbs.	......
30.	Weight of dry coal burned per hour per square foot of grate surface	lbs.	......
31.	Weight of coal burned per hour per square foot of heating surface	lbs.	......
32.	Weight of water evaporated per hour	lbs.	......
33.	Equivalent weight of water evaporated per hour with feed-water at 100° and pressure at 70 lbs.	lbs.	......
34.	Equivalent weight of water from 100° at 70 lbs. evaporated per square foot of heating surface	lbs.	......

Principal Results, Complete Engine and Boiler.

35.	Coal consumed per I. H. P. per hour	lbs.	......
36.	Coal consumed per dynamometer horse-power per hour	lbs.	......
37.	Weight of "standard coal" consumed per I. H. P. per hour	lbs.	......
38.	Weight of "standard coal" consumed for a dynamometer horse-power per hour	lbs.	......

Boiler Results.

39.	Water evaporated per pound of coal	lbs.	......
40.	Equivalent evaporation per pound of coal from and at 212°	lbs.	......
41.	Equivalent evaporation per pound of combustible from and at 212°	lbs.	......
42.	Heat imparted to each pound of steam used from average temperature of feed at average steam pressure in British thermal units		......

Cylinder Data.

43.	Mean initial pressure above atmosphere		lbs.	......
			H. P. Cyl.	L. P. Cyl.
44.	Cut-off pressure above zero	lbs.	......	......
45.	Release pressure above zero	lbs.	......	......
46.	Compression pressure above zero	lbs.	......	......
47.	Lowest back pressure above or below atmosphere	lbs.	......	......
48.	Proportion of forward stroke completed at cut-off		......	......
49.	Proportion of forward stroke completed at release		......	......
50.	Proportion of return stroke uncompleted at compression		......	......

Cylinder Results.

51. Total water consumed per indicated horse-power per hour corrected for moisture in steam............................lbs.
52. Water consumed per I. H. P. per hour by cylinders alone (from line 51 less all measured losses).......................lbs.

	H. P. Cyl.	L. P. Cyl.
53. Steam accounted for by indicators at cut-off.lbs.	......	......
54. Steam accounted for by indicators at release.lbs.	......	......
55. Proportion of feed-water used by cylinders (line 52) accounted for at cut-off.........lbs.	......	......
56. Proportion of feed-water used by cylinders accounted for at release ....lbs.	......	......
57. Total heat supplied by boiler to cylinders per hour in British thermal units.............	......	......
58. Total heat supplied by boiler to cylinders per minute per indicated horse-power in British thermal units..........................	......	......
59. Total heat supplied by boiler to cylinders per minute per dynamometer horse-power in British thermal units.....................	......	......

Reports should give a copy of a set of sample indicator diagrams, also combined diagram (in case of compound engines) and a chart showing graphically the principal data.

SUPPLEMENT.

Description of Norfolk & Western Indicator Rigging. Fig. 1, General Arrangement. Fig. 2, Details.

This form of indicator rigging involves the use of a lever (supported from the running-board by a suitable bracket), and connected at its lower end to the cross-head (by a link 12 in. long). The indicator drum cord takes its motion from a square bar working in suitable guides and connected by a short link to the main lever. In order to secure a perfectly parallel motion, the length of the cross-head link should bear the same ratio to the length of the indicator-bar link as the full length of the main lever bears to the distance from fulcrum of main lever to point of connection of the indicator-bar link. For an engine with 24-inch stroke this ratio should be 1 to 6, in order to produce an indicator card 4 inches long, and the long and short links should be 12 inches and 2 inches, respectively.

Description of Valve Motion Indicator. Fig. 3.

In this apparatus a string is wound around the groove on one end of drum, and passed over proper pulleys until it leads off in a line with the motion of the cross-head, and the other end is attached to the cross-head,

so that any motion of the piston is communicated by the cord to the drum, causing corresponding rotation.

A cord from the pen-bar is led over suitable pulleys and attached to valve rod in the same manner. The combination of the two motions, as will be seen, will give an elliptical diagram in which the abscissæ represent the position of the piston, and the ordinates the position of the valve.

Description of Boiler Lever Indicator. Fig. 4.

This apparatus consists of a spirit level mounted in a saddle which slides on an arc of a large circle. This arc is graduated, and should be sufficiently curved to operate on the heaviest grade upon which the engine will be tested.

By putting the engine on jacks or cranes, and giving different elevations to the boiler, the height of water may be measured by means of a meter to certain points on the gauge-glass, and a corresponding table made, which will denote the quantity of water in the boiler for each different angular position of the boiler. These figures can be used to make corrections on the meter readings, allowing for inclinations of the track on which the engine is standing by simply pushing the spirit lever to a horizontal position and noting the reading on the indicator.

SPECIFICATIONS AND TESTS FOR IRON LOCOMOTIVE BOILER TUBES, EXTRA QUALITY.

At the convention of 1895 the following Specifications and Tests for Iron Locomotive Boiler Tubes were adopted as standard (see page 127, report 1895); modified in 1896 (see pages 332, 333, report 1896).

Material.

Tubes to be made of knobbled hammered charcoal iron and lap-welded.

Dimensions and Weights.

Tubes 2 inches, outside diameter.

.095	inch	thick	and	weight	at least	1.91	lbs.	per foot.
.110	"	"	"	"	"	2.19	"	"
.125	"	"	"	"	"	2.47	"	"
.135	"	"	"	"	"	2.65	"	"

Tubes 2¼ inches, outside diameter.

.095	inch	thick	and	weight	at least	2.16	lbs.	per foot.
.110	"	"	"	"	"	2.48	"	"
.125	"	"	"	"	"	2.80	"	"
.135	"	"	"	"	"	3.01	"	"

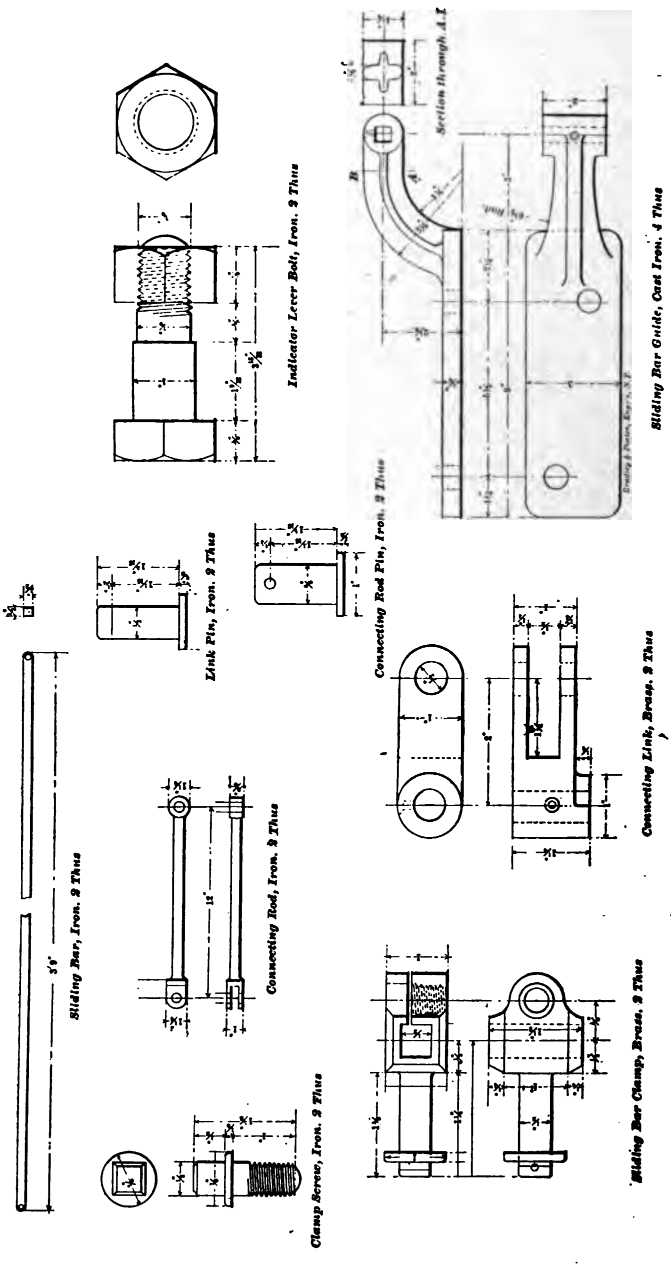
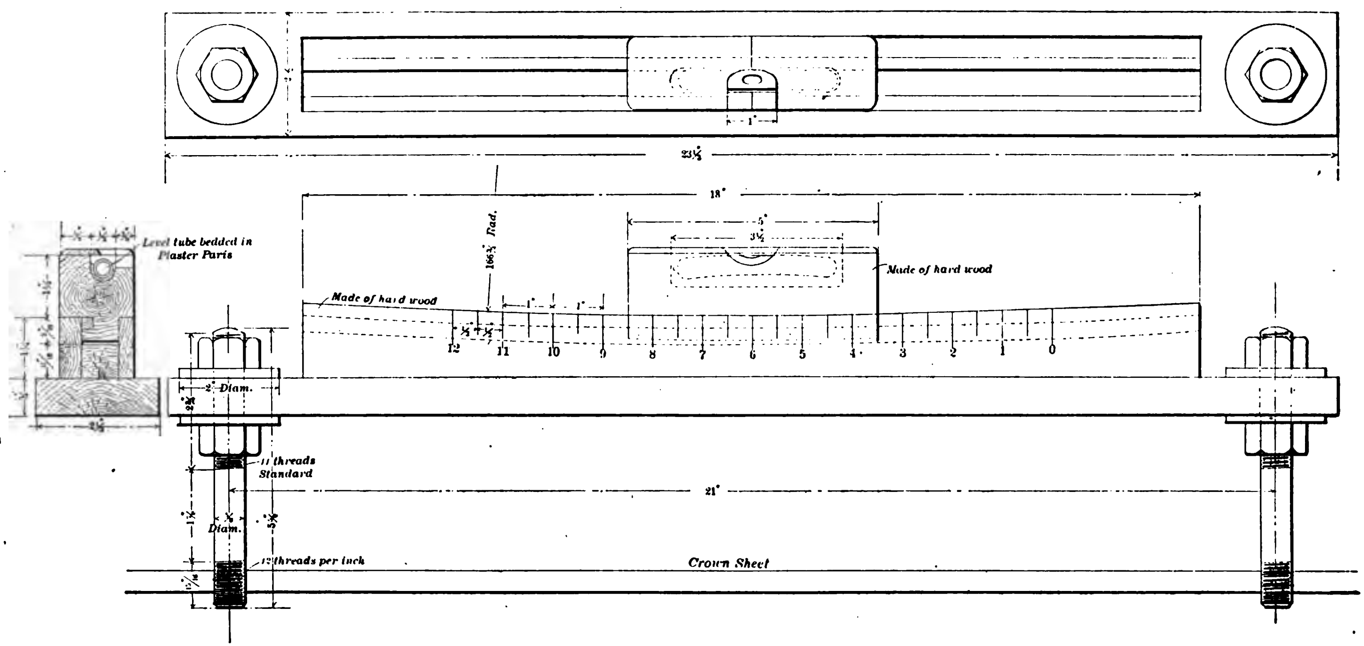

Indicator Lever Bolt, Iron. 2 Thus
Section through A.B
Sliding Bar Guide, Cast Iron. 4 Thus
Sliding Bar, Iron. 2 Thus
Link Pin, Iron. 2 Thus
Connecting Rod Pin, Iron. 2 Thus
Connecting Rod, Iron. 2 Thus
Connecting Link, Brass. 2 Thus
Clamp Screw, Iron. 2 Thus
Sliding Bar Clamp, Brass. 2 Thus

FIGURE 2.



Level tube bedded in Plaster Paris
Made of hard wood
Made of hard wood
166⅔ Rad.
23½
18"
21"
2" Diam.
11 threads Standard
12 threads per inch
Crown Sheet

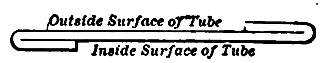
FIGURE 4.

Surface Inspection.

Tubes must have a smooth surface, free from all laminations, cracks, blisters, pits and imperfect welds. They must also be free from bends, kinks and buckles — signs of unequal contraction in cooling or injury in manipulation — and must be of uniform thickness throughout, except at weld, where .015 inch additional will be allowed, perfectly round and cut to exact length ordered.

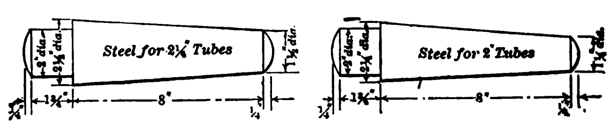
Physical Tests.

1. Strips one-half inch in width by six inches in length, planed lengthwise from tubes, after being heated to a cherry red and dipped in water at 80 degrees Fahrenheit, shall bend in opposite directions at each end as shown in sketch below, without showing cracks or flaws; and when nicked and broken these must show a fracture wholly fibrous, or a test in a testing machine may be substituted for this.



2. Sections of tubes 12 inches long — five inches of which shall be heated to *a bright cherry red in daylight* — when placed in a vertical position, and a smooth-turned tapered steel pin at a *blue heat* is driven in, by "lap" blows with a 10-pound sledge hammer, must stretch to one and one-eighth times their original diameter without split or crack. One tube to be tested, as required in paragraphs 1 and 2, in each lot of 250 tubes or less.

The sketches below show dimensions of steel pins to be used for 2-inch and 2¼-inch O. D. tubes.



3. Tubes must expand, turn over tube plate and bend down without flaw, crack or opening at weld.

Hydraulic Test.

Each tube must be subjected, by the manufacturer, to an internal pressure of 500 pounds to the square inch.

Etching Tests.

In case of doubt as to the quality of material, the following tests shall be used, namely:

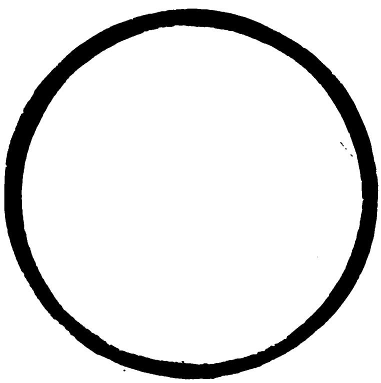
A section of tube turned or ground to a perfectly true surface, polished with fine emery paper, and free from dirt and grease, to be suspended in a bath of

Water	9 parts
Sulphuric acid	3 parts
Muriatic acid	1 part

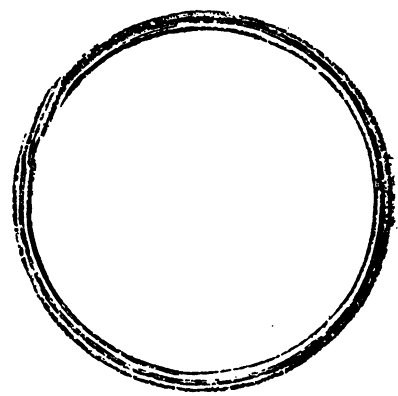
The bath should be prepared by placing the water in a porcelain dish, adding the sulphuric acid and then the muriatic acid. Chemical action is allowed to continue until the soft parts are sufficiently dissolved so that an iron tube will show a more or less finely ridged surface, with the weld very distinct.

General Requirements.

Each tube must be plainly stenciled "Knobbled Hammered Charcoal Iron" and "Tested to 500 Pounds," and tubes must be so invoiced. Each



Steel.



Charcoal Iron.

tube must also be subjected to careful surface inspection, as provided for above; and those measuring one sixty-fourth of an inch over or under the diameter ordered shall be rejected.

DECIMAL GAUGE.

At the convention of 1895 the following was adopted as a standard Decimal Gauge:

1st. The micrometer caliper should be used for laboratory and tool-room work, and in the shop when specially desired.

2d. The solid notch gauge should be used for general shop purposes.

3d. The form of this gauge shall be an ellipse whose major axis is 4 inches, the minor axis 2.5 inches, and the thickness .1 inch, with a central hole .75 inch in diameter.

1890.) Changed to Recommendations in 1891. (See pages 160, 161, report 1891.) Modified to conform to M. C. B. standard in 1903. See plate 1.

At the convention of 1903 the Master Car Builders' standard axle with 5 by 9 inch journals was adopted as standard. See report of Committee on Revision of Standards, 1903. See plate 1.

At the convention of 1903 the Master Car Builders' standard axle with journals 5½ by 10 inches was made a standard. See report of Committee on Revision of Standards. See also plate 1.

JOURNAL BOX, BEARING AND PEDESTAL.

At the convention of 1881 a design of Journal Box, Bearing and Pedestal, as shown in figs. 1, 2 and 3, was submitted and made standard for cars and locomotive tenders. (See pages 110-115, report 1881.) Changed to Recommendations in 1891. (See pages 160, 161, report 1891.) Changed to standard in 1903. See plate 14.

At the convention of 1903 the M. C. B. journal boxes and contained parts for the 3¾ by 7 inch, 4¼ by 8 inch, 5 by 9 inch and 5½ by 10 inch standard axles, as shown on plate 1, were made a standard of the Association. They are shown on plates 2 to 13, inclusive.

RECOMMENDATIONS.

At the convention in 1872 the following recommendations were adopted:

"In the matter of cost of keeping up the repairs of engines engaged in switching service exclusively, that an allowance of six miles per hour for the time that such engines are in actual use be allowed:

"That for engines running local freight trains an allowance of six per cent to the train mileage be added for switching:

"That where engines run empty to exceed one-half mile between where the trains are taken or left and the roundhouse, such mileage should be computed, and that for engines running through freight or passenger trains no computation should be made for switching:

SPECIFICATIONS AND TESTS FOR CAST-IRON WHEELS.

At the convention of 1888 the following Specifications and Tests for Cast-iron Wheels were adopted as standard. (See pages 151-154, report 1888.) In 1891 these were changed to Recommendations. (See pages 160, 161, report 1891.)

The specifications and tests are as follows:

Specifications for Cast-iron Wheels.

1. The chills in which the wheels of any one wheelmaker are cast shall be of equal diameters, and the same chill must not vary at different points more than one-sixteenth of an inch in diameter.

2. There shall not be a variation of more than one-half inch in the circumference of any given number of wheels of the same nominal diameter, furnished by any one maker, and the same wheel must not vary more than one-sixteenth of an inch in diameter. The body of the wheel must be smooth and free from slag or blow holes. The tread must be free from deep and irregular wrinkles, slag, chill cracks and sweat or beads in the throat which are one-eighth of an inch or over in diameter, or which occur in clusters of more than six inches in length.

3. The wheels broken must show clean, gray iron in the plates; the depth of pure white iron must not exceed seven-eighths of an inch or be less than three-eighths of an inch in middle of the tread, and shall not be less than three-sixteenths of an inch in the throat. The depth of the white iron shall not vary more than one-fourth of an inch around the tread on the rail line in the same wheel.

4. Wheels shall not vary from the specified weight more than two per cent.

5. The flange shall not vary in the same wheel more than three thirty-seconds of an inch from its mean thickness.

6. The single plate part of a 33-inch wheel, known as the Washburn pattern, shall not be less than five-eighths of an inch in thickness in a

wheel weighing from 550 to 575 pounds, and not less than three-fourths of an inch in thickness in a wheel weighing from 575 to 600 pounds.

Tests for Cast-iron Wheels.

1. For each hundred wheels which pass inspection and are ready for shipment, one representative wheel shall be taken at random and subjected to the following test:

The wheel shall be placed flange downward on an anvil block weighing seventeen hundred (1,700) pounds, set on rubble masonry at least two feet deep, and having three supports not more than five inches wide for the wheel to rest upon. It shall be struck centrally on the hub by a weight of one hundred and forty (140) pounds, falling from a height of twelve (12) feet. Should this wheel stand five (5) blows without breaking into two or more pieces, the hundred wheels shall be accepted. Or, wheels must be of such strength that 550 to 575 pound wheels shall require twenty (20) blows, and 575 to 600 pound wheels shall require thirty (30) blows of a hundred (100) pound drop falling seven (7) feet on the plate close to the rim to break a piece out — the wheel resting upon a cast-iron plate weighing not less than one thousand (1,000) pounds.

2. Should in either case the test wheel break into two or more pieces with less than the required number of blows, then a second wheel shall be taken from the same lot and similarly tested. If the second wheel stands the test, it shall be optional with the inspector whether he shall test a third wheel or not. If he does not so elect, or if he does and the third wheel stands the test, the hundred wheels shall be accepted.

3. The above tests shall apply to standard weight wheels from 26 inches to 42 inches diameter, used on standard gauge roads.

Form of Contract.

THIS INDENTURE, made this......day of......18.., between.......... party of the first part, and..........party of the second part, WITNESSETH:

1. The party of the first part hereby agrees to furnish to the party of the second part, free on board cars at......chilled cast-iron wheels, ... inches in diameter under the following conditions:

2. The party of the second part hereby agrees to pay to the party of the first part......dollars for each wheel furnished, and to keep an accurate record of the mileage made by the wheels placed in service under cars in passenger equipment and under locomotives and tenders, and an accurate record of the number of months of service of the wheels placed under cars in freight equipment.

3. The party of the second part hereby agrees when any wheel furnished under this contract is scrapped, to furnish to the party of the first part a statement which will show

1.—The wheel number.

2.—The service in which the wheel ran.

3.—The amount of service in months or miles.

4.—The cause of failure.

5.—A charge against the party of the first part of fifty-five per cent (55 per cent) of the price of the wheel mentioned above.

6.—A credit to the party of the first part of

....cents	per 1,000 miles	for	36 in.	passenger equipment
.... "	"	"	33 "	"
.... "	"	"	30 "	"
.... "	"	"	36 in.	locomotives and tenders
.... "	"	"	33 "	"
.... "	"	"	30 "	"
.... "	"	"	28 "	"
.... "	"	"	26 "	"
.... "	per month	for	36 in.	freight equipment
.... "	"	"	33 "	"
.... "	"	"	30 "	"

except in the case of wheels made flat by sliding, or removal for sharp flanges or other unfair treatment, which have not made sufficient service to balance the charge against the party of the first part as above; in such case a service credit shall be made which shall balance the charge.

4. The party of the first part hereby agrees that on presentation of the statement to pay to the party of the second part any balance due from lack of sufficient service on the part of the wheels (with above exceptions) to balance the charge; and the party of the second part hereby agrees to pay to the party of the first part any balance due as shown by the aforesaid statement — settlements to be made quarterly. It is, however, understood and agreed that no credit shall be allowed for excessive mileage for time service on freight wheels beyond the time guaranteed.

5. The party of the second part hereby agrees to hold, subject to the inspection of the party of the first part, for a period of thirty days after the said statement has been rendered, any wheels (with above exceptions) which have not earned for themselves a credit equal to the amount charged against them.

Service Guarantee.

36 inch passenger wheels......................	70,000 miles
33 " " "	60,000 "
36 inch engine and tender wheels	60,000 "
33 " " "	50,000 "
30 " " "	45,000 "
26 and 28 inch engine and tender wheels.......	40,000 "
Refrigerator, through line and cattle cars...	24 months
All other freight cars.........................	48 "

Settlements of claims for non-performance of guaranteed service shall be made upon the basis of mileage and time guarantee as above.

AIR-BRAKE AND SIGNAL INSTRUCTIONS.

At the convention of 1892 a code of Air-brake and Signal Instructions was adopted as Recommendation of the Association. Some modifications were made in 1898, and the modified rules are shown on pages 205-228, report 1898.

CODE OF APPRENTICESHIP RULES.

At the convention of 1898 the following code of rules was adopted as the Recommendation of the Association:

Code of Apprenticeship Rules.

1. A regular apprentice is one who has had no previous shop experience and is not a graduate of a technical institution.

2. No regular apprentice shall be taken into the shop below the age of fifteen or after the age of nineteen years.

3. No apprentice shall be taken into the shop who has not received the elements of a common education, and who does not give evidence of such capacity as to promise the ability to become a competent mechanic.

4. No apprentice shall be taken into the shop without the consent of his parents or lawful guardians, who shall have a thorough understanding of the conditions of such apprenticeship, and who shall execute such documents, including a release of the company from liability for accidents to the said apprentice, as the company may require.

5. The term during which an apprentice shall serve before receiving a certificate of apprenticeship shall not be less than three years, nor more than five years.

6. There shall be a regular apprentice course framed for each shop, which course each apprentice shall go through during his term, the time to be spent on each class of work being defined, and such definition shall be observed as closely as practicable with due regard to the capacities and condition of the individual apprentice.

7. During the term of the apprenticeship a careful and proper record shall be kept of the work and progress of the apprentice, and also of the general behavior and conduct, which record shall be entered on properly authorized blanks or books provided for the purpose not less frequently than once every week during such term.

8. Each apprentice shall be paid for the work done by him upon a scale duly agreed on and provided for in advance.

9. Under no circumstances shall the company assume any liability for the employment of an apprentice after the conclusion of his term.

10. On the conclusion of the term of apprenticeship, each apprentice shall be given a certificate in a proper form, duly signed by the proper officer of the company, which shall set forth the length of time which each apprentice has served and the work on which he has been engaged, as well as some indication of his general behavior during his term.

11. Apprentices who have already served part of a term in other shops, or who have taken part of a course at a recognized technical institution, may be received under such modifications of the foregoing rules as may be deemed proper.

Recommendations Supplementary to the Code of Apprenticeship Rules.

RULE 3. An apprentice should be able to read and write, and have a knowledge of arithmetic. Some companies insist that a candidate shall have reached a point in his studies equivalent to that of the eighth grade of the public schools. This standard, where applicable, will be found satisfactory.

RULE 4. The following is a blank form of release which is recommended as satisfactory:

APPENDIX "C."

(Form for Release of Minors.)

WHEREAS, The A. B. C. Railroad Company has agreed to take into its service ....
a minor, subject to discharge at the pleasure of the company, and has agreed with our consent to pay him the compensation to be earned for his services, and has been authorized to take from him such receipts and acquittances as the said company may require;

AND WHEREAS, The said ....
by reason of such employment, will be subjected to great risk of personal injury from neglect of other employes, agents and officers of the said company, and from defects of machinery, and from other causes;

AND WHEREAS, In the event of injuries to the said..................
.................................., whether resulting fatally or otherwise, the said..
or members of his family might make claims for damages against the said company;

NOW, IN ORDER to release the said company from all claims or liability for damages for injuries of any and all kinds, from any cause whatsoever, ...the father, and ....the mother, in their several and individual capacities, and acting as guardian for the said ...., and the said ....himself, in consideration of the employment by the said railroad company of the said ....in the service of the said company, and in consideration of the sum of one dollar now in hand paid by the said company, do hereby release and forever discharge the A. B. C. Railroad Company for all claims for damages, and do also further agree to release the said company from all claims and liability for damages arising out of any injury or injuries to the said.....................
....resulting from the

character of his employment, from the negligence of other employes, or agents or officers of the said company, from defects of machinery or any other cause or causes whatsoever, whilst a minor and whilst in the service of the said company in any capacity whatsoever.

WITNESS our hands and seals this................day of......18....

	..............................[SEAL]
WITNESSES:	..............................[SEAL]
....	..............................[SEAL]
....	..............................[SEAL]
....	..............................[SEAL]

RULE 5. Four (4) years is recommended as the best standard term. Whenever possible this should be adopted. The limits given in the rule, "not less than three nor more than five years," are made sufficiently wide to cover all special cases. The brightest and most ambitious boy should not be permitted to complete his course in less than three years under any circumstances. A boy who does not complete it in five years had better be something else than a mechanic.

RULE 6. The following courses are recommended for the various shops:

Machine Shop.

TOOL ROOM.— General use of tools, names, etc., work on small planer, drilling machine, shaper and lathes, provide tools; six months to actually serve.

ERECTING SHOP.— Helping on general work — gang No. 1, one month; helping on general work — gang No. 2, one month; helping on general work — gang No. 3, one month.

MACHINE SHOP.— General instructions, milling machine, boring mill, horizontal machine, axle lathe, and helping in general; three months to actually serve.

Boring, driving and truck brasses and quartering machine; two months.

Cylinder boring machine and planer; one month.

Rod: Rod gang, three months; small lathe (alone), two months; large slotter, one month; brass lathe, two months; small planer, one month; large and small planers, two months; driving wheel lathe, one month; large lathe (alone), two months; motion work lathe, one month; general vise work, three months; surface table, three months.

ERECTING SHOP.— General work — gang No. 1, five months; general work — gang No. 2, three months; general work — gang No. 3, four months.

Total number of months' actual service — forty-eight.

Your committee submits this as a basis for an adequate course of training in the machine shop, with the distinct understanding that it is to be qualified so far as the term of service to be spent in the different items, and also in the whole course, by the quality and capacity of the individual boys, under the discretion of whoever has them in charge.

Blacksmith Shop Course.

1. To start the apprentice on a bolt machine for six months. Here he will learn the rudiments of heating iron; also the setting and adjusting of dies, and at the same time by observation will learn the names of the tools and their use in that portion of the shop.

2. The next six months in operating a steam hammer. In this position he has a good opportunity to note how the blacksmiths handle and form iron; at the same time require him to help at the fires in the immediate vicinity of the hammer.

3. The next six months should be as a helper on a small fire, with a man who is quick and handy with light work.

4. The next six months on a light fire without a helper, where he will learn to handle the hand hammer.

5. For the next three months give him a light fire with a helper; the fire should be so located that he will be called upon to assist in taking heats for the larger fires.

6. For the next six months on heavier work that does not require skill.

7. For the next three months put him helping at the tool-dressing fire, and if the shop has two tool-dressing fires, the next three months on the second tool-dressing fire.

8. The next twelve months put him on a heavy fire with as much of a variety of work as can be arranged.

Boiler Shop Course.

1. The first three months heating light rivets.
2. The next three months helping on the heavy sheet-iron work, such as wheel covers, ash pans, etc.
3. Three months holding on rivets for tank work.
4. Three months holding on rivets for boiler work.
5. Six months riveting on patches, chipping and calking on tank work.
6. Six months setting flues.
7. Six months patching and bracing boilers, chipping and calking and general riveting.
8. Six months blacksmithing, to learn how to make and fit braces, to dress necessary tools and assist in fitting up his work.
9. The fourth year to lay out flange and do general boiler work.

RULE 7. It is recommended that some one person be given direct charge of all apprentices and be held responsible for their proper instruction. He can be known as "the Foreman of Apprentices," or he can be designated to perform the duties, without special title, in conjunction with his ordinary work. The following blank page for an Apprentice Record Book is recommended:

APPRENTICE RECORD.

NAME.	WEEKS.																			Total Weeks Worked.	Average Credit. Conduct and Ability.
	1	2	3	4	5	6	7	8	9	10	11	2	13	14 up to 52 weeks							
John Doe	80	50	90	70	50	30	90	80	70	50	30	90	80	70	40	70	80	50	30		63
James Smith																					
Chas. Jones																					

RULE 8. The scale of pay must be governed largely by geographical and individual conditions. It is recommended that the rate of pay be 50 cents for a ten-hour day for the first year, with an increase of 25 cents a day for each year thereafter. For an eight-hour day 40 cents a day at the start and 20 cents a day increase yearly.

RULE 9. The following form of certificate is recommended:

APPENDIX "B."

(Form of Certificate of Apprenticeship.)

A. B. C. RAILROAD COMPANY,

MOTIVE POWER DEPARTMENT.

CERTIFICATE OF APPRENTICESHIP.

....
has served an apprenticeship as..
at the shops of this Company at...
during the period from........................to......................
and has made................hours' time over 10 hours per day.

WORK ON WHICH EMPLOYED.

APPROXIMATE NO. OF MONTHS.	KIND OF WORK.
....	....
....	....
....	....

OFFICERS UNDER WHOM EMPLOYED.

NAME.	TITLE.
....	....
....	....
....	....

GENERAL RECORD OF APPRENTICE.

....
....

Supt. Motive Power.

RESOLUTIONS.

Revised and modified at convention, 1903.

At the convention of 1886 the following resolutions prevailed:

Resolved, That this Association deprecates the giving of testimonials or recommendatory letters for publication, and enjoins all to restrict matters of this nature to letters of inquiry. (See page 26, report 1886.)

Resolved, That it is the sense of this convention that in practice it is unnecessary to bead flues in the front end. (See page 152, report 1886.)

At the convention of 1888 the following resolution prevailed:

Resolved, That it is the sense of the Master Mechanics' Association that the pilots of all engines should have steps placed on the front end for the safety and convenience of brakemen while coupling at the front ends. (See page 162, report 1888.)

At the convention of 1893 the following resolution prevailed:

Resolved, That while the Master Mechanics' Association regards the water glass as a convenience and an additional precaution against low water, we do not regard it as an absolute necessity to the safe running of locomotives. (See page 161, report 1893.)

At the convention of 1896 the following resolutions prevailed:

Resolved, That it is the sense of this meeting that the radial stay boiler is as safe as the crown bar boiler, and that the former is easier to keep clean and more economical in repairs. (See page 280, report 1896.)

Resolved, That it is the sense of this Association that the statement of the performance of locomotives should be made on the basis of train load, in lieu of train miles or loaded car miles, as is the prevailing practice at present. (See page 333, report 1896.)

At the convention of 1899 the following resolutions prevailed:

Resolved, That it is the sense of this convention that the time has not arrived when we can abandon instructions to those who use the air-brakes, but that the time has arrived when we should perhaps take more care to instruct those who repair the brakes and keep them in order. (See page 71, report 1899.)

Resolved, That it is the sense of the American Railway Master Mechanics' Association that the use of fusible plugs in the crown sheets of locomotive fire-boxes is not conducive to the prevention of the overheating of the crown sheet. (See page 153, 1899 report.)

Resolved, That it is the sense of this Association that the ton-mile basis for motive power statistics is the most practical, and encourages economical methods of operating; and that it is desirable that the heads of motive power departments urge its adoption on their managements. (See page 173, report 1899.)

Resolved, That it is the sense of this Association that it is not advisable to use bars in exhaust nozzles. (See page 277, report 1899.)

At the convention of 1901 the following resolutions prevailed:

Resolved, That it is the sense of this Association that a strict comparison of motive power statistics, one road with another, will not secure the best results, but that such comparisons should be made with the records of the same division for preceding periods of time. (See page 79, report 1901.) (See modification, page 70, 1902 report.)

Resolved, That it is the sense of this Association that the ton-mileage of the locomotive is a just credit to the motive power department for statistical purposes. (See page 83, report 1901.) (See modification, page 77, 1902 report.)

Resolved, That it is the sense of this Association that it is necessary that the side rods should be on engines traveling from the works to the railroad they are built for. (See page 99, report 1901.)

At the convention of 1902 the following resolutions prevailed:

"*Resolved,* That it is the sense of this Association that conclusions based on a comparison of the statistics of one railroad with another may easily prove incorrect, should be given less weight than they usually are, are just only when the accompanying conditions are fairly well known and their influence can be determined with some degree of accuracy; that a comparison of the statistics of a division or a system with those of the same territory for a previous corresponding period very largely eliminates these uncertainties and makes conclusions based on such a comparison much more reliable."

"*Resolved,* That it is the sense of this Association that the ton-mileage of the locomotive and caboose is a just credit to the motive power department for statistical purposes."

"*Resolved,* That the ton-mile is the best practical basis now available for motive power and operating statistics by which to judge the efficiency of locomotive and train service.

"*Resolved,* That actual tonnage should be used in computing ton-mile statistics for comparison with those of other roads, but for comparison with the previous records of the same system or division the use of adjusted tonnage is advisable.

"*Resolved,* That the statistics of passenger, freight, work train and switching services should be on the ton-mile basis, each service in a separate group, and passenger and freight service to be each further grouped under Through and Local.

"*Resolved,* That the statistics of branch lines and main lines should be kept separately.

"*Resolved,* That the credit of ton-mileage for locomotives in switching service should be proportional to their tractive power.

"*Resolved,* That the ton-mileage of trains using more than one locomotive should be divided among the locomotives attached to these trains in proportion to their tractive power and for the distance over which the helping locomotives are used.

"*Resolved,* That the tonnage of the locomotive should be its weight in working order, plus the light weight of the tender and half its capacity of coal and water."

Obituary.

MR. WILLIAM SWANSTON.

Mr. Swanston was born in Glasgow, Scotland, on May 11, 1827, and received his technical education at the Glasgow Mechanics' Institute. He came to this country in 1849 and entered the railway service as machinist on the Little Miami Railroad at Pendleton, Ohio, in 1850. He was promoted to gang foreman and then to general foreman of these shops, remaining there until 1866. From 1866 to 1871 he was Master Mechanic of the Cincinnati, Sandusky & Cleveland Railroad, at Sandusky, Ohio. From there he went to the Burlington, Cedar Rapids & Northern Railroad, as Master Mechanic, remaining until 1872. From November, 1873, to April, 1876, he was Assistant Master Mechanic of the Little Miami Railroad, at Columbus, Ohio. From April, 1876, to November, 1879, he acted in the same capacity at Indianapolis, Indiana, on the Jeffersonville, Madison & Indianapolis Railroad, and in November, 1879, he was promoted to Master Mechanic of the same road at Jeffersonville, Indiana. When the Indianapolis shops of the Pennsylvania Lines were built in 1884, he was made Master Mechanic at that point, and held this position until the first of January, 1901, when he was retired in accordance with the pension system of the Pennsylvania Lines West of Pittsburg. He died on March 4, 1903, after a short illness.

Mr. Swanston was one of the founders of the American Railway Master Mechanics' Association, always taking an active interest in these affairs. In spite of his years, he took a keen interest to the last in everything pertaining to railroad matters, and kept up to date and in touch with all improvements. He was loved and respected by the men under his charge and by all those with whom he was associated. His services on the Pennsylvania Lines covered a period of forty-seven years, and was practically coincident with the development of the American locomotive. His experience included much that was interesting and instructive, and for this reason always carried great weight with his superior officers.

He was always willing and ready to impart his education to the younger generations under him and thus help them to make progress in their work.

I feel that it is but just to have the opinion, in this connection, of a man who was closely associated with him as his Superintendent of Motive Power. The attached testimonial from Mr. S. P. Bush, I feel, needs no comment, except possibly, my personal observations of the feeling of the men under his charge toward him while I was his assistant:

"The death of William Swanston, recently Master Mechanic of the Indianapolis shops of the Pennsylvania Lines, has removed from among the railway mechanical men one of the broadest and ablest men in the profession.

"It is but fair to class him as one of the pioneers in this country, for his early training and work was with such men as Reuben Wells, who was the first to construct and operate a locomotive of high tractive power on a grade so steep as to be considered impracticable by eminent engineers of the day.

"Mr. Swanston was associated with Mr. Wells at that time and assisted in the design and construction of these heavy engines. He was one of the founders of the American Railway Master Mechanics' Association, and always an active participant in its proceedings.

"A close association with him for a number of years enabled me to know him intimately, and I can say with the utmost confidence, that, first as man and citizen, and afterward as a mechanic and executive, he fulfilled every possible expectation. He was so well trained and balanced that I have never heard him spoken of as lacking here or there, and as my own associate in railway work and under very difficult conditions, he never failed to meet every contingency that arose.

"He was of that sturdy Scotch race, and had all of its best characteristics — great courage, a fine sense of justice and a love for his fellow man — that attracted others to him very strongly, and, once attached, it was always so, and this is the best evidence of quality.

"His fine character, coupled with his knowledge of men and things, gave him an unusually strong personality. His employes, his coördinate [illegible] superior officers, all loved and respected him alike, and now that he is gone, there is no discordant [illegible] no one to say aught against him. If he had any fault, it was modesty. Had he less of this he might have improved [illegible] his material welfare and extended his influences and usefulness over a wider field, but he would have been no better [illegible]

When he was retired [illegible] the pension system of the [illegible] requested him to meet them and [illegible] in the faces of the [illegible] doubt, the power [illegible] and the love and [illegible]

S. W. Miller.

MR. JACOB LOSEY.

Jacob Losey was born in Dover, New Jersey, May 10, 1828. He died in Louisville, Kentucky, July 27, 1902.

He was educated in the Newark schools and learned his trade with Mr. Seth Boyden, of Newark, a great inventor and machinist. He was foreman in the machine shops of Hewes & Philips, in Newark, until August, 1853, when he went to Milwaukee, Wisconsin. He was there two years, and in 1855 went to Detroit, Michigan, to take a position in the Detroit Locomotive Works. From Detroit he went to Michigan City, Indiana, and became Master Mechanic of the Michigan Central Railroad. He was in charge there three years, when he accepted the position of Master Mechanic of the L. N. A. & C. R. R., at New Albany.

He was president of the New Albany Steam Forge Works until 1881, when he moved to Louisville to organize the Louisville Steam Forge Company, which position he held as superintendent until the time of his death, covering a period of over twenty years.

His wife, two sons and one daughter survive him.

Mr. Losey was a member of the American Railway Master Mechanics' Association since 1868. H. SWOYER.

MR. W. L. HOLMAN.

Mr. W. L. Holman was born at Connellsville, Pennsylvania, January 10, 1834, and died in Brooklyn, New York, January 7, 1903, of diabetes. At the age of twenty-one years he entered the service of the Pennsylvania Railroad Company at Altoona, in the machine shop, under instructions. He left the service of the above company August, 1857. February, 1860, he again entered the service of the Pittsburg, Fort Wayne and Chicago Railway as a machinist, was promoted to assistant roundhouse foreman in 1861, continued in this position until 1865, at which time he took service with the Oil Creek Railway as machinist, and remained with this company until 1867. On February 20, 1867, he was appointed Master Mechanic of the Kane shops at Kane, Pennsylvania, on the Philadelphia & Erie Division of the Pennsylvania Railroad Company. He was transferred from there to Renovo and made roundhouse foreman May 1, 1880, on account of closing of Kane shops. On November 1, 1881, he was

appointed Master Mechanic of the Renovo shops at Renovo, on the Philadelphia & Erie Division of the Pennsylvania Railroad, and remained in this position until his death.

Mr. Holman's first marriage was to a Miss Morrow, of Pittsburg, who died of consumption. He had two children by this marriage. Both are dead and buried at St. Marys, Pennsylvania. He was married a second time to Mrs. Kate B. Carter, on September 19, 1888, who survives him. There were no children by this marriage. He became a member of the Master Mechanics' Association in 1885.

Mr. Holman never received a technical education, yet he was progressive. He was a man who never expressed himself on the floor of the convention, yet his faithfulness, combined with his ability and familiarity with all branches of railroad service, made him of great value to the road with which he was connected. It was always a pleasure to converse with him on such topics. He was a man of strong personality and a self-made man in every sense of the word, loved and respected by all who knew him, and his moral character was above reproach.

W. C. Arp.

MR. PETER E. GARRISON,

Master Mechanic of the Steam and Electric divisions of the Fonda, Johnstown & Gloversville Railroad, died very suddenly in his office Friday, August 22, 1902. Mr. Garrison was fifty-nine years of age, and was born in Paterson, New Jersey. He served an apprenticeship in the old Cooke Locomotive Works, of Paterson, and was afterward connected with the Greenwood Lake Railroad, now a division of the Erie Railroad.

During the years 1883 to 1886 the writer was associated with Mr. Garrison in the Mechanical Department of the West Shore Railroad, he at that time being the General Foreman of the Frankfort shops. During the nineties, Mr. Garrison was made division Master Mechanic at Buffalo, and remained with that company until December, 1897, when he went with the Fonda, Johnstown & Gloversville Railroad. When he entered the employ of that road, he had very little experience with electricity, but, realizing that it was the coming motive power, he studied it thoroughly and was soon a competent authority on motive power on both the Steam and Electric divisions.

In referring to his death, President Hees paid Mr. Garrison a high tribute to his worth as a Master Mechanic and a man, stating that his death was an almost irreparable loss to the company.

In 1871, Mr. Garrison married Miss Mary Haggerty, of Port Jervis, New York, who followed him in death within nine months, the cause of her death being attributed to silent grief.

Mr. Garrison joined the Association in 1892. He was not so well known as many who have taken a more active part in its meetings. His work and service for the Association was of a quiet nature, and his means of distributing knowledge of mechanical matters, of which he was more than ordinarily possessed, was in conversation with his associates rather than in debate.

He was a loyal friend, and one of the men that helped make this world the better for their living in it. GEO. W. WEST.

MR. GEORGE H. PRESCOTT.

Mr. Prescott was born at Gilford, New Hampshire, October 18, 1826, and died December 30, 1902. He entered the service of the Concord & New Hampshire Railroad, as fireman and machinist apprentice, in 1846. After serving his time on this line and being promoted to engineman and machinist, he resigned to accept a position on the Central Railroad of New Jersey as engineman. Remaining only a short time on this road, he entered the service of the Amoskeag Locomotive Works. He remained with this company until the works were closed, due to the panic of 1857. From 1857 to 1868, Mr. Prescott was employed by the Baldwin Locomotive Works; except for a short period, he was in the engineering corps, surveying the Baltimore & Potomac Railroad. In 1868 he went to the Cattawissa Railroad, remaining there until 1872, when he came west to take charge of the Pittsburg, Cincinnati, Chicago & St. Louis Railroad shops at Logansport, Indiana, as Master Mechanic. He remained in this capacity until September 15, 1882, when he went to the Vandalia Lines at Terre Haute, Indiana, as Superintendent of Motive Power, which position he held until February 1, 1896. Then, again, he was reëmployed by the Vandalia Lines as General Foreman at Logansport on April 1, 1898, and was retired on the pension list December 31, 1900. He became a member of the American Railway Master Mechanics' Association in 1873.

J. J. ELLIS.

MR. EDWARD GRAFSTROM.

Edward Grafstrom, Mechanical Engineer of the Atchison, Topeka & Santa Fe Railway System, lost his life at Topeka, Kansas, on June 2, 1903, while engaged in rescuing his fellow townspeople from the flood. When the Kansas river overflowed its banks the end of May, the water

rose to the height of twelve feet in some of the streets, and thousands of people sought refuge in trees and upper stories of buildings. The current was so swift in some places that row-boats could make no headway, and the relief commissioners requested the Santa Fe Railway shops to build a gasoline launch. Mr. Grafstrom and several others worked out the design of the boat Sunday, May 31, and by continuous shop labor it was completed Tuesday morning about 6 o'clock.

At the urgent request of Mr. Grafstrom, he was authorized to organize a crew, and with this boat and crew he started in the brave work of rescue as captain of the little craft at 8:30 A.M. The boat accommodated twenty-five people, and a total of seventy-seven persons were rescued from the upper stories of buildings, many of these structures being in danger of collapsing from the undermined foundations.

On the final trip over this day, with a crew of seven only aboard, the launch was capsized by fouling a sunken tree. All the crew were rescued but Mr. Grafstrom, and even the sad satisfaction of a Christian burial was denied, as his body was never found, in spite of long and diligent searches. He left a widow, but no children.

He was born at Motola, Sweden, December 19, 1862, and was educated at Orebro Classical University and at Boras Technical University, receiving the degree of Mechanical Engineer at the age of nineteen. In 1882, he connected himself with the Pennsylvania Railroad at Altoona, and later was promoted to Columbus, Ohio, when, in 1892, he was appointed Mechanical Engineer of the Pennsylvania Lines. In May, 1900, he came to the Santa Fe as Mechanical Engineer, having previously served in the same capacity for a few months with the Illinois Central.

Mr. Grafstrom was a member of the American Society of Mechanical Engineers, American Railway Master Mechanics' Association and Master Car Builders' Association, and took an active part in these societies. He was also a member of the First Congregational Church in Topeka. Tall and commanding in appearance, with a model physique, and at all times a perfect gentleman, he was universally honored and admired. His technical labors were no less highly regarded than his personal attainments. His noble sacrifice was the loss of the community. G. R. HENDERSON.

MR. ELLIOT F. MOORE.

Elliot F. Moore, formerly Mechanical Engineer in the office of the Commissioner of Railroads in the State of Michigan, was born at West Fairlee, Vermont, June 7, 1847. His education was received in the district schools of his native village and in the Newburg Seminary of Vermont,

where he had nearly completed a preparatory course for college, when, in 1863, he left school, came to the home of an uncle in Michigan and enlisted as a member of the First Michigan Engineers and Mechanics, and served with them until the close of the war.

After his discharge from the army, Mr. Moore entered the employ of the Flint & Pere Marquette Railroad Company and continued with that company, serving in different capacities until his appointment as Mechanical Engineer in 1893.

He served in this position for five and one-half years, making a competent and efficient official and becoming popular with the general public, as well as the railroad officials with whom he came in contact, on account of his uniformly courteous and affable manner and the thoroughness and impartiality of all his official acts.

After his retirement from the office of the Commissioner of Railroads, he was employed for several months by the State Tax Commission, as an expert assisting in the appraisal of the railroad property in the State, and rendered the Commission valuable service.

Upon the completion of this work, he returned to the service of his old company, now the Pere Marquette Railroad Company, and while running as a locomotive engineer on a fast passenger train, was killed in a collision at Plymouth, January 11, 1901, the accident being caused by no fault of his, but by the negligence of a fellow employe.

Mr. Moore was not only a thoroughly first-class mechanic and engineer, but he was a genial, companionable gentleman, and his death was sincerely mourned by a large circle of friends and acquaintances throughout the entire State of Michigan. He became an associate member of the American Railway Master Mechanics' Association in 1897.

FRANCIS W. LANE.

MR. JOHN A. QUINN.

Mr. John A. Quinn was born at Sandusky, Ohio, September 23, 1840. His father was a prominent merchant in that old lake city. He was educated in the public schools of Sandusky and afterward graduated with high honors from the high school of that city. He served his apprenticeship on the old Mad River Railroad, one of the first roads built in the State of Ohio, and now a part of the Big Four System.

Mr. Quinn rose steadily in his business. He attracted attention to the extent that he was appointed Master Mechanic of the Carroll, Vincennes & Western Railroad, going from there to the Pittsburg & Western Railroad, and about the year 1890 was appointed Master Mechanic of the Clifton Forge Division of the Chesapeake & Ohio Railway Company.

Mr. Quinn was of a most kindly disposition and was loved and respected by all who knew him.

His health commenced to fail about September 1, 1902. He tendered his resignation, which would not be accepted by the management of the Chesapeake & Ohio Railway, but he was allowed an indefinite vacation under full pay. His strength, however, continued to gradually fail him until January 7, 1903, when he departed this life at Clifton Forge, Virginia. He is survived by his wife, son and daughter.

Mr. Quinn became a member of the American Railway Master Mechanics' Association in 1888. J. F. WALSH.

STILMAN A. HODGMAN.

Mr. Stilman A. Hodgman was born at Stoddard, New Hampshire, April 8, 1831. He came from that sturdy old Puritan stock that has made New England notable, his ancestors being among the earliest settlers in Massachusetts and New Hampshire. On his mother's side he descended from the Joslyns, who settled in what is now Leominster, Massachusetts, in 1632, and later moved to New Hampshire. He was educated in the schools of Lowell, Massachusetts, and at the age of seventeen went to work in a woolen mill in Manchester, New Hampshire. At the expiration of two years he returned to Lowell and entered the works of the Locks and Canal Machine Company to serve a three years' apprenticeship. After about two years his employer, Mr. Colby, removed to Philadelphia and he completed his apprenticeship in Waltham, Massachusetts. His first experience in locomotive work was in 1851, at the Hinckley & Drury shops in Boston, Massachusetts. In 1852-03 he was with Hittinger and Cook, machine and engine builders, Charlestown, Massachusetts.

In 1854 Mr. David Upton, then Mechanical Superintendent of the Rochester, Lockport and Niagara Falls R. R., offered him a position in the shops of the company at Rochester, New York, which he accepted. Mr. Upton was a native of Stoddard and well knew Mr. Hodgman's antecedents and ability; he was also one of the ablest railroad men of his time, and under his supervision Mr. Hodgman learned the business thoroughly. After a year in the shops he spent two years on the road as locomotive engineer, and in 1857 returned to the shops and was made foreman of the machine department, and soon after was promoted to be General Foreman, which position he filled with great ability. During this time he designed and built several locomotives which were regarded as models of design and efficiency.

In 1864 he accepted the position of Assistant Master of Machinery of the Philadelphia, Wilmington & Baltimore R. R., under Mr. George W.

Perry, and removed to Wilmington, Delaware. In the spring of 1872 he resigned to become General Superintendent of the Wilmington & Western R. R., a new line then under construction westward from Wilmington. Under his management the road was completed and placed in operation the following October, when he returned to the P. W. & B. R. R., having been appointed Master of Machinery, to succeed Mr. Perry. He held this position until 1883, when he resigned to become Mechanical Superintendent of the Lobdell Car Wheel Company, in which capacity he served until, on account of failing health, he retired from active duty April 6, 1901. On the 17th of October, 1902, Mr. Hodgman met with a most painful accident, causing a clot of blood at the base of the brain, and after lingering in great suffering for nearly four weeks he died on the 12th of November, 1902.

Mr. Hodgman became a member of the American Railway Master Mechanics' Association in 1870, and during the earlier years of the Association took an active part in the work. At the meeting held at Alexandria Bay, in 1895, he was elected an honorary member, after having been an active member for twenty-five years. He was also for many years a Mason and a Knight Templar.

Mr. Hodgman was twice married, his first wife having died in Wilmington in 1873. One son by his first marriage learned the machinists' trade and afterwards entered Stevens' Institute of Technology, taking one of the Master Mechanic scholarships, graduating in 1895. He was employed by the Baldwin Works for about two years, when he went to the republic of Colombia, in South America, to superintend the erection of a new locomotive for the Ferrocaril del Couca. Shortly after his arrival at Buenaventura he was stricken with yellow fever and died in a few days, far in the mountains of the interior, where he had been hurried in the hope of saving his life. His death under these distressing circumstances was a great shock to Mr. Hodgman, from which he probably never fully recovered. One daughter by this marriage is still living, and his second wife, two sons and one daughter also survive him.

Probably the best work of Mr. Hodgman's life was accomplished while he was with the P. W. & B. R. R., and his thoroughly efficient, progressive and economical management while at the head of the Locomotive Department constitute a record which has seldom been equaled. During his connection with the road he designed and built about thirty new locomotives, besides rebuilding many others, and when the road passed under the control of the Penna. R. R., in 1883, its motive power had the reputation of being equal in appearance and efficiency to any railroad in the country. He was a very progressive man and always kept fully abreast of the times. He was one of the earliest advocates of the use of steel for fire boxes and boilers, and as early as 1867 built boilers wholly of steel plates. He was also among the first to take up the practice of substituting injectors for pumps and of equipping his locomotives with extension fronts.

Mr. Hodgman was a devout member of the Baptist Church, and a large-hearted, broad-minded, Christian gentleman, whose sterling character won for him the profound respect and confidence of all who knew him. He combined in a rare degree a genial, whole-souled good fellowship, which made him a welcome companion, with an almost Puritan loyalty to principle, to truth and to honor. In business he was impatient of slovenly or superficial work, stern though merciful in dealing with dereliction of duty, but thoroughly appreciative of honest effort and always deeply sympathetic in trouble or misfortune. Notwithstanding the responsible executive positions held by Mr. Hodgman, involving constant and almost independent direction of many subordinates, his natural modesty guarded him from arrogance and the arbitrary manner which is apt to come with long exercise of authority. Taken altogether he was a fine type of genuine manhood, winning his way by his own efforts, faithful to every trust reposed in him, incomparable in his integrity, a true husband, a faithful friend and an honored citizen. H. D. GORDON.

WILBUR CLARENCE DALLAS.

Wilbur Clarence Dallas was born February 13, 1857, and died January 22, 1903. Mr. Dallas entered the service of the Galena-Signal Oil Company as Mechanical Expert in August, 1889. Prior to that time, during the year 1886, he was Roundhouse Foreman of the Chicago, St. Paul, Minneapolis & Omaha Railway, and in 1887 was Shop and Roundhouse Foreman of the Wisconsin Central Railway. He left that position in August, 1889, and accepted a position with the Galena-Signal Oil Company and continued with that firm until August, 1901, when he accepted the position of Assistant Superintendent of Motive Power of the Missouri Pacific Railway. He resigned on June 1, 1902, on account of ill health, returned east, and accepted service as traveling representative of the Franklin Manufacturing Company. He became a member of this Association in 1888.

The following excerpt from the resolutions adopted by the mechanical experts of the Galena-Signal Oil Company, with whom he was associated, fittingly describes the man:

"No one who ever knew him will fail to recall some quality he possessed unusual among men or in a higher degree. His mind was clear and strikingly original. His moral courage was strong and he flattered no man; yet his nature was kindly, and for his friends his love was abiding. He was without pretense, and was content to stand before men for what he was. His character is best described by saying that he was

an honest man in the widest sense. He loved his family with unmeasured devotion, and in the kingly qualities of husband and father he measured high. When his health became broken and he saw the inevitable end, his courage did not fail him and he talked of death with a brave spirit. He took leave of life as becomes one who has nobly done his part."

JOSEPH W. TAYLOR.

ALONZA A. HENDEE.

Alonza A. Hendee was born in Cuba, Allegany County, New York, in 1843, and removed to Ohio with his parents ten years later. In 1862, when but nineteen years of age, he enlisted his services in the cause of the Union. In due time he received an honorable discharge and, later, reënlisted in the Sixth United States Regular Volunteer Infantry for four years. During this time, he was made Second Lieutenant and saw considerable active service in the Indian campaigns. He began railroading when about twenty-four years of age, was a locomotive engineer for twenty years, and afterwards held the position of Master Mechanic on various roads. Mr. Hendee was the founder of the Brotherhood of Locomotive Engineers in the City of Mexico. During the construction of the Mexican Central Railway, he lived for three years in a box car and took the first official train over the road. He spoke Spanish fluently and his services were deemed of special value in the Spanish-speaking countries. From 1885 to 1887 he was Master Mechanic of the Jacksonville, Tampa & Key West R. R., and took service with the Westinghouse Air Brake Company about the time of the Burlington brake trials, by which company he was sent to Mexico and various Central American republics in the interests of the air brake. Later he became Master Mechanic of the Isthmus of Panama Railway Company and of the steamship lines between New York and the Isthmus. It was while engaged in this work that Mr. Hendee's health began to fail him and his condition finally became so serious that he was brought back to his home in Columbus, Ohio, where he died Sunday, March 16, 1902. In addition to being connected with a number of secret socities, he was a Mason, a member of the Knights Templars, Wilmington Commandery, Wilmington, Ohio, and the funeral services were conducted under the auspices of that body. Interment was in the family vault at Newark, Ohio. He left a widow and one married daughter.

Mr. Hendee, who became a member of the American Railway Master Mechanics' Association in 1886, was a thorough mechanic of excellent judgment and possessed inventive faculty in a degree. Personally he was modest, retiring and little disposed to discuss his achievements. He

rendered valuable and efficient service in the various capacities in which he was employed, was universally esteemed and respected, and his death came as a shock not only to those who knew his worth through official connections, but also to that wide circle who, with deep sorrow, mourn his loss as a loyal and faithful friend. E. M. HERR.

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PAST PRESIDENTS.

H. M. BRITTON, . .	1868 to 1876.	Deceased.
N. E. CHAPMAN, . .	1876 " 1880.	Deceased.
J. N. LAUDER, . .	1880 " 1882.	Deceased.
REUBEN WELLS, . .	1882 " 1884.	
JOHN H. FLYNN, .	1884 " 1885.	Deceased.
J. DAVIS BARNETT, .	1884 " 1885.	Acting President.
J. DAVIS BARNETT, .	1885 " 1886.	
WILLIAM WOODCOCK, .	1886 " 1887.	Deceased.
JACOB JOHANN, . .	1886 " 1887.	Acting President.
J. H. SETCHEL, . .	1887 " 1889.	
R. H. BRIGGS, . .	1889 " 1890.	
JOHN MACKENZIE, . .	1890 " 1892.	
JOHN HICKEY, . .	1892 " 1894.	
W. GARSTANG, . .	1894 " 1895.	
R. C. BLACKALL, .	1895 " 1896.	
R. H. SOULE, . . .	1896 " 1897.	
PULASKI LEEDS, .	1897 " 1898.	
ROBERT QUAYLE, . .	1898 " 1899.	
J. H. McCONNELL, .	1899 " 1900.	
W. S. MORRIS, . .	1900 " 1901.	
A. M. WAITT, . .	1901 " 1902.	
G. W. WEST, . . .	1902 " 1903.	